GEI Consultants, Inc.

INSTRUMENTATION APPENDIX TO PERIODIC INSPECTION REPORT NO. 6 BLACKWATER DAM WEBSTER, NEW HAMPSHIRE

Submitted to:

Department of the Army
New England District
Corps of Engineers

1021 Main Street
Winchester, MA 01890-1970
(781) 721-4000

November 1997
Project 97494

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Gillian Gregory

Gillian M. Gregory, Ph.D.
Project Manager

EXECUTIVE SUMMARY

This report provides a summary and evaluation of geotechnical instrumentation of the Blackwater Dam in Webster, New Hampshire. The Blackwater Dam was constructed for flood control purposes and is a combination earthfill embankment and concrete gravity dam.

Geotechnical instrumentation at the dam consists of four crest monuments and a brass disc set in a concrete wall at the intake structure and six piezometers. Plate 6 shows the locations of the geotechnical instrumentation.

Crest Monuments

Four crest monuments and the brass disc on the intake structure (Mons. 1 through 5, labeled by station) were installed in October 1975. There are also four control points labeled A, B, C, C-1 composed of brass discs set in ledge or concrete. Surveys for horizontal control were performed by the Corps of Engineers (COE) in 1978, 1986, 1991, and 1996. However, due to changes in surveying methods, only the 1991 and 1996 surveys are directly comparable with respect to horizontal movement. Vertical movement surveys were performed in 1975, 1978, 1986, 1991, and 1996. Vertical movement data are comparable for all five surveys. Survey data are presented on Plates 10 and 11. Computed horizontal and vertical movements were small with a maximum horizontal movement of 0.16 foot (1.9 inches) between 1991 and 1996. Given the resultant direction of the movement, the movements recorded at other crest monuments, and the fact that visual inspections by the COE have shown no evidence of adverse movements at the dam, this amount of movement is not considered significant. The maximum net vertical movement recorded since 1975 is 0.059 foot (0.71 inch) of settlement at monument 10+05.738. This amount of settlement is considered to be insignificant.

Piezometers

The COE installed six piezometers in the embankment to comply with COE guidelines recommending minimum instrumentation for COE dams. The piezometers were installed at about Station 7+60. Two piezometers were installed in a borehole located on the upstream slope, two in a borehole located on the crest, and two in a borehole located on the downstream slope. The piezometer locations are shown on Plate 6. Table 1 gives the station, offsets, boring numbers, and elevations of key piezometer features. Plates 7, 8, and 9 give the engineering logs of the boreholes and piezometers. Plates 12 and 13 show a cross section through the dam at Station 7+60 showing the piezometer locations and piezometer data. Boring logs, piezometer logs, and the results of the falling head tests on the piezometers are shown as Plates A.1 through A.49.

The COE project personnel measured piezometer pore water elevations according to the reading schedule provided as Plate B.3 since November 1994. Table 2 lists measured pore water depths in the piezometers from October 1994 through April 1997. Table 3 lists measured pore water elevations in the piezometers from October 1994 through April 1997. Table 3 data are plotted as time histories on Plates C.1 and C.2. The piezometer time history data for the high pool event in April 1996 are shown on Plates D.1 and D.2. Plots of piezometer pore water elevation vs. pool elevation are shown on Plates E.1 through E.6.

An average piezometer pore water elevation was calculated for each piezometer based on the monthly data excluding the daily data collected during high pool periods. Table 4 lists the selected piezometer data used to calculate the average piezometer levels along with the calculated averages. Based on the plots of piezometer pore water elevation vs. pool elevation, projections were made of the likely piezometer pore water elevations for a flood pool at spillway crest. These projections are shown on Plates E.1 through E.6 and are listed in Table 5. Plate 13 shows the average piezometer levels, the maximum piezometer levels recorded during the April 1996 high pool event and the projected piezometer levels for a flood reaching spillway crest.

Conclusions and Recommendations

Based on past performance of the dam and on the performance of the instrumentation to date, the Blackwater Dam appears to be suitably instrumented. Existing instrumentation indicates that the dam embankment is functioning suitably relative to seepage and crest movements.

Comparison of data between 1991 and 1996 indicates displacements in the range of 0.08 to 0.16 foot (1 to 2 inches). The displacements are mostly in a northerly direction, which is almost along the axis of the dam. The crest monument data show that movements are generally small and, taken together with past COE visual inspection reports indicating no evidence of adverse movements, can be considered insignificant.

The crest monuments should continue to be surveyed and evaluated on the current schedule of once every five years just prior to the periodic inspection.

The piezometer data only cover one cross section and have only been collected for 2-1/2 years. However, the data collected to date indicate that the dam is functioning as expected. Piezometer data from deep piezometers indicate water levels close to those that would have been found in the ground prior to construction. The upstream piezometer in the embankment, PZ-1B, shows water levels that rise with rising pool levels, although there was considerable scatter in the data. The readings obtained from piezometer PZ-1B fluctuated more than would be expected, and thus this piezometer should be investigated and, if needed, replaced. Data from the two downstream

embankment piezometers indicate that the impervious core is working to cut off the downstream side of the embankment from the pool. We consider the number of piezometers installed to be adequate, unless physical evidence of unusual seepage patterns observed in the future indicates the need for additional instrumentation.

The current schedule of monitoring the piezometers is adequate.

PREFACE

Purpose and Scope

This report provides a summary and evaluation of geotechnical instrumentation of the Blackwater Dam in Webster, New Hampshire.

GEI performed the following work:

a) Reviewed Periodic Inspection Reports 1 through 5 and data provided by the U.S. Army Corps of Engineers (USACE) on August 19, 1997. (Tasks 1 and 2)

b) Prepared an instrumentation general plan in a Microstation drawing file. (Task 3)

c) Prepared drafted engineering logs and piezometer logs, profiles, and cross sections in Microstation drawing files. (Tasks 4 and 5)

d) Prepared Lotus 1-2-3 plots of piezometer data. (Task 6)

e) Prepared a phreatic surface plan in a Microstation drawing file. (Task 7)

f) Prepared survey data and horizontal and vertical movement plots in Microstation drawing files. (Task 8)

g) Prepared this report summarizing Tasks 1-8. (Task 9)

Project Personnel

Gillian M. Gregory	Project Manager
Carolyn Lewis	Civil Engineer
Dana MacLeod	Lead Drafter
R. Lee Wooten	In-House Reviewer

Elevation Datum

All elevations in this report are referenced to National Geodetic Vertical Datum (NGVD).

Limitations

Our professional services for this project have been performed in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

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1.0 PROJECT PERFORMANCE

Based on visual observations reported in past reports (Refs. 1 through 5[1]) and a review of the instrumentation data, the performance of the dam is considered to be good. The crest monument survey data indicate that very little vertical movement occurred during the 21-year period from 1978 to 1996 (0.06 foot of settlement to rise of 0.01 foot). Data obtained from horizontal movements could be compared only between 1991 and 1996 due to a change in survey method and the replacement of control points in 1991. However, horizontal movements appear to be very small (0.08 to 0.16 foot over the period 1991 to 1996). Data from piezometers installed during 1994 indicate that groundwater levels in the foundation remain close to those that would have been found in the ground prior to construction. Piezometric levels in the embankment upstream of the impervious core fluctuate with changes in pool level as would be expected. The water levels in the embankment downstream of the core indicate that the impervious core is working to cut off the downstream side of the embankment from the pool.

[1]References are listed at the end of the text.

2.0 GENERAL PROJECT DESCRIPTION

2.1 History

2.1.1 General

The Blackwater Dam and Reservoir are part of a system of five dams and reservoirs that have been constructed to provide flood control on the Merrimack River Watershed in the states of New Hampshire and Massachusetts. This system of dams and reservoirs provides protection for the lower reaches of the river including the cities of Concord, Manchester, and Nashua in New Hampshire and Lowell, Lawrence, and Haverhill in Massachusetts.

The Blackwater Dam and Reservoir are located in the Town of Webster, New Hampshire, on the Blackwater River 8.6 miles above its confluence with the Contoocook River, which is a major tributary of the Merrimack River. It was the second project to be constructed in the system of flood control reservoirs in the Merrimack River Basin. These projects were authorized by Section 5 of the Flood Control Act approved on June 22, 1936, which was subsequently modified by Section 4 of the Flood Control Act approved on June 28, 1938. A definite project report on the Blackwater Dam was submitted on September 15, 1939 and modified by a revised report that was submitted on December 16, 1939 and was approved on January 18, 1940. These Acts provided for a system of flood control reservoirs on the Merrimack River and its tributaries. The first reservoirs constructed were the Franklin Falls Dam and Reservoir on the Pemigewasset River and the Blackwater Dam and Reservoir on the Blackwater River. Construction of the Blackwater Dam started in the spring of 1940 and was completed in November 1941.

2.1.2 Past Flood Events

a. April 1996 Flood: During April 1996, the reservoir level reached an elevation of 550.0, its highest level during the period October 1994 through April 1997. This elevation represents a stage of 35.0 feet, 16 feet below spillway crest (24% full). The reservoir level also reached El. 550.0 during October 1996, but the flood event was of shorter duration.

b. April 1987 Flood: During April 1987, the embankment was subjected to its highest impoundment to date with a maximum water surface elevation of 564.1 feet NGVD, 49.1 feet stage (1.9 feet below spillway crest), 90 percent full. An Emergency Response Team from Geotechnical Engineering Branch

inspected the dam during the event and prepared a First Impressions Report. The observations were that the dam embankment and dikes were in generally good condition and performing satisfactorily. There were audible sounds of seepage under the rock fill between Stas. 7+00 and 7+50 about 10 feet up the slope of the downstream toe. Small amounts of seepage accumulation appeared in the old river channel, but there were no signs of sediment transport. There were no signs of boils along the downstream toe or indications of movement of the slopes.

c. June 1984 Flood: During May-June 1984, the embankment was subjected to its third highest impoundment with a maximum water surface elevation of 556.2 feet NGVD, stage 41.2 feet (9.8 feet below spillway crest), 48 percent full.

d. April 1969 Flood: During April 1969, the embankment was subjected to its second highest impoundment with a maximum water surface elevation of 561.6 feet NGVD, stage 46.6 feet (4.4 feet below spillway crest), 74 percent full.

2.2 Geology and Foundations

2.2.1 General

The Blackwater Dam site is located in the north central Merrimack River Basin in the center of Merrimack County, New Hampshire. The dam impounds water from the Blackwater River, a major tributary of the Contoocook River, which, in turn, flows into the Merrimack River. Physiographically the area is located in the New England upland section. Elevations range from around 500 feet (NGVD) at river level to over 800 feet (NGVD) on the nearby hills. The river valley at the site is asymmetric with the river channel in a rock gorge against the left valley wall, which rises abruptly. A secondary channel exists to the right of the rock gorge; this is a broad, shallow flood channel.

The overburden on both abutments is a sandy glacial till, and the valley fill is an alluvial deposit consisting generally of gravelly sands. The flat valley upstream of the dam may be sediments of a former glacial lake caused by a natural damming from glacial debris.

The local bedrock consists of granite and gneiss and is near the contact of a gneissic facies of the Devonian Littleton Formation, which has been intruded by the Kinsman Quartz Monzonite.

2.2.2 Site Geology

At the dam site the river flows in a narrow bedrock gorge, about 20 feet in depth, located along the base of the left abutment. The adjacent valley is about 600 feet wide and has generally been eroded to bedrock by overflow of flood discharges from the main river channel. Bedrock is either exposed or accessible over the entire valley bottom, rarely exceeding 15 feet in depth. Bedrock is exposed on the east bank of the river, plunges to about 15 feet below the till at the extreme left abutment, and is generally shallow downstream of the centerline. However, upstream from the dam centerline the bedrock dips, with the overburden varying to about 40 feet in depth beneath the upstream toe. The overburden on the right abutment is a sandy glacial till containing some silt and numerous cobbles and boulders. The left abutment is quite variable, ranging from slightly silty sand to very silty sand and gravel with numerous boulders. The overburden downstream from the centerline of the dam consists of a shallow alluvial deposit ranging from a fine silty sand to gravelly sand with numerous cobbles and boulders. Upstream of the centerline, the overburden consists generally of a uniform silty fine sand with some fine sandy silt and fine to medium sand.

The bedrock at the site is a coarse crystalline granite, with gneissic inclusions and quartz veins. The bedrock is structurally sound except for the top few feet of weathering. An ancient and inactive fault striking N 28 degrees E is located about 100 feet downstream of the dam centerline and dips 45 degrees SE. Three joint sets are present; two of these are major sets well developed in the gneiss and trending about N-S and E-W and are frequently intruded with granite. These joints are nearly vertical. The third set strikes about N 45 degrees E and dips about 55 degrees SE. The bedrock is fractured to the degree that a careful grouting program was required to prevent seepage beneath the dam embankment. Pressure testing of the drill holes revealed some of the joints were sufficiently open to lose water at a rate of 14 gallons per minute at depths ranging from 20 to 75 feet. Rock grouting was done at several locations along the dam centerline. The grout holes were 2.5 inches in diameter and drilled 5 feet between centers at alternating depths of 20 and 40 feet.

2.3 Dam and Appurtenant Structures Description

The Blackwater Dam is a combination earthfill embankment and concrete gravity dam. The maximum height of the dam is 65 feet. The crest of the embankment is at elevation 584.0 feet NGVD and is 38 feet, 10 inches wide and 875 feet in length. The spillway crest is at elevation 566.0 feet NGVD and is 242 feet in length. The dam has an upstream slope of 1 on 3 and a downstream slope of 1 on 2.5. There are also two earthfill dikes in the upper reaches of the reservoir.

The earthfill embankment consists of a rolled earthfill section with an upstream zone of dumped rock fill and a small downstream rock toe. The right abutment and a major portion of the dam is composed of this earthfill structure with a rock blanket on the upstream slope and a grass surface on the downstream slope. The earth fill contains a central core of compacted impervious fill flanked by compacted pervious fill zones. The impervious fill extends to the surface of the grouted bedrock for the full length of the embankment and is a very silty sandy glacial till containing about 10 percent clay particles. Pervious fill material consists primarily of a silty sandy glacial till with some gravel sizes and also of suitable material from the required excavations. The downstream pervious fill zone is underlain by a 3-foot-thick sand and gravel drainage blanket leading to the downstream dumped rock toe to control any seepage through the bedrock and impervious core. Materials for the rock fills were obtained from the required rock excavation and by culling boulders out of the borrow areas.

The central portion of the dam is a concrete non-overflow section that was constructed with a 16-foot, 0-inch diameter penstock as part of provisions for a future power installation. This penstock was filled in with a precast concrete plug as part of the construction contract. The left section and abutment is a concrete ogee weir overflow section. There are three 3'6" x 5'3" gated flood control outlets in the overflow section. Normally, these gates are set in the open position to provide for the unrestricted flow of the river. The dam as constructed also had a 3'6" x 6'6" ungated outlet to discharge the normal river flow. This outlet was permanently plugged with concrete in July 1951 to increase the effectiveness of the reservoir during flood regulation.

There are also two earthfill dikes in the upper reaches of the reservoir, the Dodge Estate Dike and the Little Hill Dike. These two dikes are rolled earth similar to the dam embankment. Dodge Estate Dike has a maximum height of 18 feet and is founded on a moderately compact, well graded, silty, sandy glacial till overlying bedrock to a depth of about 50 feet. Little Hill Dike has a maximum height of 38 feet and is founded on variable, silty to gravelly glacial till containing numerous boulders with a cut-off trench to bedrock at a depth of 5 to 15 feet.

3.0 INSTRUMENTATION

3.1 Crest Monuments

Instrumentation to monitor embankment performance at the Blackwater Dam consists of four crest monuments and a brass disc set in a concrete wall at the intake structure. There are also four control points at locations off the embankment. There is no instrumentation on either the Dodge Estate Dike or the Little Hill Dike. The four crest monuments are located along the centerline of the dam embankment crest (Plate 6). The monuments were installed in October 1975, and post-installation surveys were performed in 1978, 1986, 1991, and 1996 by Corps of Engineers (COE) New England Division Surveyors. The depth and composition of the monuments is unknown, except for the brass discs in place on the surface. It is assumed that the monuments are 5 feet in depth and composed of 4-inch-diameter PVC pipe filled with concrete and steel reinforcing bar. The monuments are labeled as follows: Mon. 1 (Sta. 2+91.639), Mon. 2 (Sta. 4+90.558), Mon. 3 (Sta. 6+89.537), and Mon. 4 (Sta. 8+88.550). The brass disc at the intake structure is labeled Mon. 5 (Sta. 10+05.738). The four control points are labeled A, B, C, and C-1 and are composed of brass discs set in ledge or concrete (Plate 6). Control points A and B are along the line of sight of the crest monuments, one at each abutment. Control points C and C-1 are downstream of the dam. The current standards and procedures employed by COE Surveyors for crest monument surveys are shown on Plates B.1 and B.2.

3.2 Piezometers

Piezometers were installed in the embankment in July 1994 to comply with COE regulations regarding minimum instrumentation at COE dams (Ref. 5). The locations of the piezometers are shown on Plate 6. Two piezometers were installed in each of three boreholes drilled along a cross section at approximately Sta. 7+60 (PZ-1A&B, PZ-2A&B, and PZ-3A&B). Within each borehole, one piezometer was installed near the interface between the embankment soils and foundation soils, and one was installed within the foundation soil or rock (Table 1 and Plate 12). Boring logs and piezometer installation logs are shown on Plates A.1 through A.49. Graphic logs for the three borings and six piezometers are shown in Plates 7-9. All piezometers are Casagrande-type with 3/4-inch PVC riser pipes and are manually read using an M-Scope Water Level Indicator. Data collection commenced in October 1994.

4.0 DATA COLLECTION, INTERPRETATION, AND EVALUATION

4.1 Crest Monuments

4.1.1 Data Collection

Results of crest monument surveys, including elevations and horizontal coordinates of crest monuments, control points, and the brass disc at the intake structure, from 1975, 1978, 1986, 1991, and 1996, are shown on Plates 10 and 11. Plate 10, Crest Survey Monuments, General Layout, shows results including distances between control points and crest monuments as well as coordinates for these points from the survey performed in 1996. Elevations of crest monuments and the brass disc at the intake structure from all surveys are also included. A graphical depiction of vertical displacement for each monument and the horizontal displacement since 1991 are shown on Plate 11.

4.1.2 Interpretation and Evaluation

The 1986, 1991, and 1996 surveys utilized an electronic distance meter (EDM) with Third Order, Class II accuracy (1:5000) for horizontal measurements and Third Order, Class I accuracy (1:10,000) for vertical measurements according to the standards and procedures outlined in Appendix B, Standards for Settlement Surveys. The 1975 and 1978 surveys used different instruments and procedures. Vertical data from all five surveys are comparable, but horizontal data are not.

The surveys indicate that the maximum vertical movement occurred at crest monument 3 (Sta. 6+89.537) and was equal to 0.084 foot (1.008 inches) of rise, occurring between 1975 and 1978. However, the total survey period is 21 years, and the most recent survey from 1996 shows the rise at this monument equal to only 0.013 foot (0.156 inch) for the 21-year period from 1975 to 1996. This indicates an apparent settlement of this monument from 1978 to 1996. Maximum settlement occurred at crest monument 4 (Sta. 8+88.550) and was equal to 0.035 foot (0.42 inch), occurring between 1975 and 1996. Other monuments showed lesser amounts of rise or settlement. The brass disc at Mon. 5 (Sta. 10+05.738) had a settlement of 0.059 foot (0.708 inch).

The rises and settlements just described are within the margin of error for the survey methods used, and it is likely that no rise or settlement actually occurred. The magnitude of any of the vertical movements are so small that they may be considered negligible, regardless of whether the movements are considered actual rise or settlement of the embankment or of the monument itself.

The four surveys also determined horizontal positions for the crest monuments and control points. However, the 1986, 1991, and 1996 surveys reported positions in the State Plane Coordinate System and used averaged field angles and EDM distances to calculate horizontal coordinates. Earlier surveys used EDM distances with calculated angles. Error will be introduced if 1986, 1991, or 1996 horizontal data are compared with earlier data; the two methods are not compatible and do not provide comparable results. In addition, 1986 and 1996 horizontal data are not directly comparable as the control points all changed for 1991 due to the loss of the earlier points. Therefore, only 1991 and 1996 horizontal coordinates are included in this report.

Based on the survey data from 1991 and 1996, the greatest horizontal movement of a crest monument is 0.16 foot (1.9 inches) at Mon. 1 over the five-year time period. All movements tended to be in a northerly direction, along the axis of the dam (Plate 11). This amount of movement is small when the survey accuracy is taken into account.

It has been noted in the previous periodic inspections of this dam that there was no physical evidence of movement at any crest monument, such as slumps, scarps, cracks, or depressions. These would be expected if significant movement had taken place in the embankment. Although survey data are inconclusive, the lack of any physical manifestation of movement leads to the conclusion that no significant horizontal movement of the embankment has occurred.

4.2 Piezometers

4.2.1 Data Collection

a. Location Maps: A general plan of the project showing the location of the active piezometers and the corresponding identification number for each piezometer is provided to project personnel to eliminate identification and data recording inaccuracies.

b. Data Collection Tables: A table listing the piezometer identification number, stationing and offset, as well as piezometer top and tip elevations is also provided for recording and submitting piezometer readings.

c. Reading Schedule (See Plate B.3): Piezometer monitoring at Blackwater Dam has been maintained by project personnel since the installation of the piezometers in 1994. The minimum piezometer reading schedule presently in effect is as follows:

(1) Routine: During periods when the reservoir is at or below the 20-foot stage (El. 535 feet NGVD), readings should be made by the project manager at least once a month. Along with these readings, the previous 24-hour rainfall, time of reading, and pool stage should be recorded. When access to instruments is made hazardous by snow or ice, the readings may be deferred until safe access is possible.

(2) High Pool: During periods when the reservoir level (includes rising and falling pools) is above the 20-foot stage, readings should be made on a daily basis. Pool elevations, time of reading, and previous 24-hour rainfall should be recorded simultaneously with piezometer readings. On a falling pool, piezometer readings should continue for approximately five days after the pool has returned to 5-foot stage (El. 520).

d. Special Conditions: If unusual changes in readings develop or if piezometers become inoperable, Geotechnical Engineering Division should be contacted.

Readings obtained from the piezometers are compiled in Table 2. Pertinent information includes the date and time of reading, pool elevation, and the depth to water below the top of the piezometer riser pipe. Actual water elevations are compiled in Table 3.

4.2.2 Interpretation and Evaluation

a. Presentation of Data: Plots have been developed to display the piezometric data. All the plots were developed using Lotus 1-2-3 computer software spreadsheet.

Time-history plots for the years 1994-1997 for each piezometer are shown as Plates C.1 and C.2. A time-history plot was developed for the April 1996 flood event for each piezometer and is presented as Plates D.1 and D.2. X-Y plots of piezometer water elevation vs. pool elevation developed for each piezometer are shown as Plates E.1 through E.6. These plots reflect all piezometric data received to date. Also plotted is a projection of the piezometric level corresponding to a pool at spillway crest.

b. Individual Piezometer Response: All pertinent information (station, offset, top and tip elevations, zone and material type where tip is located) for each piezometer is listed on Table 1 and Plates 7-9. Falling head tests were performed immediately after completion of installation. These tests confirmed that all piezometers are in working order. The results of these tests are shown on Plates A.14 - A.17, A.31 - A.34 and A.46 - A.49.

As described in Section 2, Blackwater Dam does not have a recreational pool. Unrestricted flow of the Backwater River is allowed through three gates in the concrete ogee weir at the left end of the dam, the normal river level being about at El. 518. Most of the embankment fill section of the dam is at elevations greater than the normal river elevation.

(1) PZ-1A: PZ-1A is located on the upstream slope, at about Sta. 7+60, with its tip in foundation soils at El. 520.7. The tip is surrounded by filter sand extending from El. 516.9 to 526.7, which is capped with a 4-foot bentonite seal. The foundation material that influences the response of PZ-1A is a thin zone of greenish silty (10-20%) GRAVEL (GM) that overlies bedrock. The normal groundwater level in PZ-1A ranges from about El. 523.5 to El. 533 over the period 1994 to 1997 (Table 3). The time-history plots (Plates C.1 and D.1) show that the rise in piezometric elevation closely follows the rise in pool level, with either no lag or a lag of one to two days at most in response. The peak piezometer levels are very similar to the peak pool levels, indicating a close hydraulic connection between the piezometer and the pool, probably through the gravel. However, the piezometric levels remain perched about 9 feet above the river level after the pool levels fall. This is because the existing ground level was at about El. 532 prior to dam construction, and thus the water levels generally return to about this elevation during times of normal flow in the river. A dip in the time-history plot (Plate C.1) in January 1996 appears to be merely a bad reading and not part of a trend. The projected piezometric elevation with pool level at spillway crest is 561.3 (Plate E.1).

(2) PZ-2A: PZ-2A is located on the downstream edge of the crest, at about Sta. 7+60, with its tip in foundation material at El. 515.9. The tip is surrounded by filter sand extending from El. 513.5 to 521.8, which is capped with a 4-foot bentonite seal. The foundation material that influences the response of PZ-2A is a gray coarse granitic GNEISS The normal groundwater level in PZ-2A ranges from about El. 527.5 to El.

534.5 over the period 1994 to 1997 (Table 3). The time-history plots (Plates C.1 and D.1) show a rise in piezometric elevation with rise in pool level, with a lag of a couple of days in response. The normal piezometric level remains perched about 13 feet higher than the normal river level but does not rise much in response to rise in pool level, indicating that the impervious core provides a good seepage cutoff. The normal piezometric level is consistent with probable pre-construction groundwater levels in the area. A spike in the time-history data on 4/12/97 (Plate C.1) appears to be the result of a transposition of numbers between PZ-2A and PZ-3A on the data sheets. The projected piezometric elevation with pool level at spillway crest is 541.3 (Plate E.2).

(3) PZ-3A: PZ-3A is located on the downstream slope of the dam, at about Sta. 7+60, with its tip in foundation material at El. 513.8. The tip is surrounded by filter sand extending from El. 512.9 to 520.8, which is capped with a 4-foot bentonite seal. The foundation material which influences the response of PZ-3A is a gray coarse granitic GNEISS. The normal groundwater level in PZ-3A ranges from about El. 528 to El. 532 over the period 1994 to 1997 (Table 3). The time-history plots (Plates C.1 and D.1) show a rise in piezometric elevation with rise in pool level, with a lag of a couple of days in response. The normal piezometric level remains perched about 13 feet higher than the normal river level but does not rise much in response to rise in pool level, indicating that the impervious core provides a good seepage cutoff. The normal piezometric level is consistent with likely pre-construction groundwater levels in the area. A dip in the time-history data for 4/12/97 (Plate C.1) appears to be the result of a transposition of numbers between PZ-2A and PZ-3A on the data sheets. The projected piezometric elevation with pool level at spillway crest is 534 (Plate E.3).

(4) PZ-1B. PZ-1B is located on the upstream slope, at about Sta. 7+60, with its tip in embankment soils at El. 532.7. The tip is surrounded by filter sand extending from El. 530.7 to 536.7, which is capped with a 4-foot bentonite seal. The material which influences the response of PZ-1B is a gray silty (15-25%) SAND with trace of gravel (SM). The normal groundwater level in PZ-1B ranges from about El. 535.5 to El. 538 over the period 1994 to 1997 (Table 3). The time-history plots (Plates C.2 and D.2) show that the piezometric level rises in response to rising pool level, but that the piezometric level remains elevated after the pool level drops. The

response time varies from zero to a lag of two days. A dip in the data in April 1996 appears to be a single erroneous reading and not part of an adverse trend. The peak piezometric level in PZ-1B during floods is often slightly higher than the peak pool level recorded (by up to 0.6 foot), which may be due to rainfall infiltrating the embankment or simply inaccuracies in the measurement techniques. Perched infiltration or instrument inaccuracies may also be the reason that the average normal piezometric level in PZ-1B is about 9 feet higher than the level in PZ-1A. There was a lot of scatter in the PZ-1B data (Plate E.4). Due to scatter in the data, the piezometric elevation with pool level at spillway crest was not estimated.

(5) PZ-2B: PZ-2B is located on the downstream edge of the crest, at about Sta. 7+60, with its tip in the impervious core at El. 527.8. The tip is surrounded by filter sand extending from El. 525.8 to 533.3, which is capped with a 4-foot bentonite seal. The material that influences the response of PZ-2B is a gray silty (20-30%) SAND w/trace of gravel (SM). The normal groundwater level in PZ-2B ranges from about El. 533.5 to El. 534.8 over the period 1994 to 1997 (Table 3). The time-history plots (Plates C.2 and D.2) show a slight response of PZ-2B with rise in pool level, indicating that the impervious core is cutting off the downstream part of the dam from the reservoir. The normal water level in PZ-2B is about 14 to 16 feet higher than the normal water level in the river but not inconsistent with the probable pre-construction groundwater levels. The water level in PZ-2B is slightly higher (3-6 feet) than in PZ-2A and is probably caused by perched infiltration. A peak in the data on 8/28/96 appears to be merely an erroneous reading. The projected piezometric elevation with pool level at spillway crest is 536.1 (Plate E.5).

(6) PZ-3B: PZ-3B is located on the downstream slope of the dam, at about Sta. 7+60, with its tip in embankment soils at El. 526.8. The tip is surrounded by filter sand extending from El. 524.8 to 532.8, which is capped with a 4-foot bentonite seal. The material which influences the response of PZ-3B is a brown silty (10-20%) SAND with gravel (SM). The normal groundwater level in PZ-3B ranges from about El. 528 to El. 532 over the period 1994 to 1997 (Table 3). The time-history plots (Plates C.2 and D.2) show very little response of PZ-3B with rise in pool level, indicating that the impervious core is cutting off the downstream part of the dam from the reservoir. The normal water level in PZ-3B is about 10 feet higher than the normal water level in the river but is consistent

with likely pre-construction groundwater levels. The water level in PZ-3B is very similar to the level in PZ-3A, indicating that both piezometers are in zones of similar groundwater flow and drainage characteristics. A dip in the data on 7/7/95 appears to be merely an erroneous reading. The projected piezometric elevation with pool level at spillway crest is 534 (Plate E.6).

c. Profile Evaluation: Cross sections through the dam at Sta. 7+60 are shown in Plates 12 and 13. Plate 12 shows the boring data, and Plate 13 shows the piezometric data discussed above. Based on the boring logs shown in Plate 3 and Plate 7, PZ-1A is located in the natural gravelly, sandy soils overlying bedrock. PZ-2A and PZ-3A are located in bedrock. All three piezometers show a hydraulic connection to the reservoir by responding to rises in pool elevation, although the responses in PZ-2A and PZ-3A are lower, probably because the gravelly sandy soils around PZ-1A are more permeable than the bedrock around PZ-2A and PZ-3A.

PZ-1B, PZ-2B, and PZ-3B are all located within embankment soils, near the interface with the foundation. PZ-1B is located upstream of the impervious core of the dam, and piezometer response shows a direct hydraulic connection to the pool as would be expected, although there is a lot of scatter in the data (Plate E.4). The estimated phreatic surface in the embankment for the April 1996 high pool event is shown on Plate 13. PZ-2B is located in the impervious core, and PZ-3B is located downstream of the impervious core. Both show very little change in piezometric level with change in pool elevation, also as would be expected. In addition, when the river is at its normal level, piezometric levels are lower in PZ-3B than in PZ-2B and lower in PZ-2B than in PZ-1B.

All piezometers show piezometric water levels at normal pool that are higher than the normal river elevation of about 518, indicating that water remains "perched" within the embankment. This is probably due to the fact that the piezometer alignment at Station 7+60 coincides with a low area (see Plate 4 profile) on the original flood plain profile at about El. 530 to 532. Groundwater flow to the river in this area is probably impeded, causing the normal levels measured in the piezometers to be higher than the river level. The "perched" water levels are likely consistent with pre-construction groundwater levels in the area.

The water levels in PZ-1B are generally higher (up to 12 feet) than in PZ-1A. This may be caused by the compacted pervious fill around PZ-1B being slightly less permeable than the foundation material around PZ-1A. This could lead to rainfall infiltrating the embankment and remaining perched, while the response of PZ-1A is unaffected by rainfall.

There was considerable scatter in the data obtained for PZ-1B. While the piezometer may be reacting more to rainfall infiltrating the embankment than to changes in pool elevation, it is also possible that the piezometer is not working properly.

Maximum groundwater levels are shown on Plate 14. Due to there being only six piezometers, no contours were shown.

In conclusion, piezometric levels measured between 1994 and 1997 appear to be consistent with expectations.

5.0 CONCLUSIONS

5.1 General

Based on past performance of the dam and on the performance of the instrumentation to date, the Blackwater Dam appears to be suitably instrumented. Existing instrumentation indicates that the dam embankment is functioning suitably relative to seepage and crest movements.

5.2 Crest Monuments

5.2.1 Schedule

The planned schedule for crest monument surveys for the Blackwater Dam is once every five years, which coincides with the periodic inspection schedule. This schedule is adequate unless physical evidence of embankment movement is found or the next scheduled survey results in unusual readings. Therefore, the next scheduled survey should be performed in 2001, just prior to the periodic inspection.

5.2.2 Evaluation of Adequacy

The number and locations of the crest monuments are adequate to evaluate embankment movements. However, changes in survey methods between 1986 and 1991 mean that horizontal movement data prior to and following that time cannot be compared. Comparison of data between 1991 and 1996 indicates displacements in the range of 0.08 to 0.16 foot (1 to 2 inches). The displacements are mostly in a northerly direction, which is almost along the axis of the dam. The maximum settlement between 1975 and 1996 is 0.035 foot (0.42 inch). In the absence of any reported physical evidence to indicate embankment movement, these displacements and settlements are not considered significant.

5.2.3 Recommendations

The crest monuments should continue to be surveyed and evaluated on the current schedule.

5.3 Piezometers

5.3.1 Schedule

The current schedule of monitoring the piezometers is adequate.

5.3.2 Evaluation of Adequacy

At present, only one cross section has been instrumented with piezometers. However, the data collected to date indicate that the dam is functioning as expected. In the absence of any physical indications at the site of unusual seepage patterns, we believe that the current instrumentation is adequate.

5.3.3 Recommendations

We recommend that piezometric monitoring should be continued on the current schedule. Piezometer PZ-1B should be investigated and, if needed, replaced because there was a lot of scatter in the data. The need for additional piezometers should be assessed if future piezometric data or physical evidence at the site indicate unusual seepage patterns that would warrant further study.

REFERENCES

1. Department of the Army (1971). "Periodic Inspection Report No. 1 - Blackwater Dam & Reservoir, Blackwater River, Webster, New Hampshire," New England Division, Corps of Engineers, February.

2. Department of the Army (1978). "Periodic Inspection Report No. 2 - Blackwater Dam, Blackwater River, New Hampshire," New England Division, Corps of Engineers, August.

3. Department of the Army (1983). "Periodic Inspection Report No. 3 - Blackwater Dam, Blackwater River, New Hampshire," New England Division, Corps of Engineers, May.

4. Department of the Army (1987). "Periodic Inspection Report No. 4 - Blackwater Dam, Blackwater River, New Hampshire," New England Division, Corps of Engineers, October.

5. Department of the Army (1992). "Periodic Inspection Report No. 5 - Blackwater Dam, Blackwater River, New Hampshire," New England Division, Corps of Engineers, October.

TABLE 1 - PIEZOMETER DATA - MATERIAL ZONES
Instrumentation Appendix
Blackwater Dam, Webster, New Hampshire

Piezometer No.	Station	CL Offset (ft)	Riser Pipe Top Elev. (ft-NGVD)	Piezometer Tip Elev. (ft-NGVD)	Zone	Material Tip Is Located In
PZ-1A	7+60	34 (U)	583.6	520.7	Foundation	Greenish silty GRAVEL (GM)
PZ-1B	7+60	34 (U)	583.7	532.7	Embankment	Gray silty SAND w/trace of gravel (SM)
PZ-2A	7+60	10 (D)	587.2	515.9	Foundation	Gray coarse granitic GNEISS
PZ-2B	7+60	10 (D)	587.3	527.8	Embankment	Gray silty SAND w/trace of gravel (SM)
PZ-3A	7+60	62 (D)	567.2	513.8	Foundation	Gray coarse granitic GNEISS
PZ-3B	7+60	62 (D)	567.3	526.8	Embankment	Brown silty SAND w/gravel (SM)

U = Upstream
D = Downstream

TABLE 2 - PIEZOMETER DEPTH READINGS
Instrumentation Appendix Report
Blackwater Dam

DATE	TIME	POOL ELEV.	Tailwater Stage	DEPTH READINGS, METERS PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
10/12/94	1000	516.3	2.36	18.11	14.68	18.02	16.40	11.85	11.87
11/03/94	1000	516.8	2.57	18.23	14.51	18.13	16.28	11.93	11.93
12/02/94	1130	518.4	3.19	18.32	14.63	18.20	16.43	11.94	11.93
12/30/94	1000	531.5	2.34	16.43	14.50	16.86	16.48	11.00	11.03
12/31/94	1200	519.4	3.44	16.16	14.44	16.78	16.51	10.96	11.00
01/01/95	1200	521.2	3.65	16.07	14.20	16.69	16.38	10.93	10.97
01/02/95	1245	521.3	3.67	16.18	14.10	16.73	16.29	10.96	11.01
01/03/95	1000	521.0	3.39	16.15	14.08	16.75	16.27	10.93	11.02
02/01/95	1000	519.0	3.57	16.78	13.95	17.00	16.18	11.10	11.15
03/06/95	1345	517.7	2.89	17.55	14.41	17.25	16.35	11.16	11.16
04/03/95	130	520.0	3.89	16.78	14.48	16.82	16.23	10.92	10.95
04/14/95	1000	536.4	2.55	14.65	14.04	16.41	16.06	10.76	10.84
04/15/95	900	537.4	2.56	14.25	14.00	16.26	16.05	10.74	10.78
04/16/95	830	538.1	2.55	13.95	13.92	16.18	16.05	10.69	10.75
04/17/95	1000	539.0	2.57	13.75	13.90	16.13	16.13	10.66	10.75
04/18/95	1000	539.3	2.47	13.71	13.89	16.10	16.08	10.62	10.71
04/20/95	1100	540.0	NA	13.41	13.50	16.00	16.03	10.56	10.60
04/21/95	900	539.6	2.92	13.43	13.55	16.01	16.08	10.60	10.69
04/22/95	1000	540.0	2.92	13.41	13.48	16.00	16.05	10.58	10.66
04/23/95	900	540.1	4.25	13.43	13.50	16.01	16.06	10.56	10.66
04/24/95	900	540.1	2.94	13.28	13.15	15.89	16.05	10.52	10.61
04/25/95	1000	539.8	3.75	13.28	13.11	15.93	16.04	10.54	10.62
04/26/95	1230	539.0	3.75	13.32	13.14	15.88	16.08	10.56	10.66
04/27/95	1000	538.6	3.72	13.34	13.16	15.92	16.12	10.60	10.69
04/28/95	915	539.0	2.59	13.32	13.14	15.88	16.08	10.56	10.66
04/29/95	1000	538.4	2.92	13.34	13.16	15.92	16.12	10.61	10.70
04/30/95	1330	535.6	5.02	14.10	13.07	16.15	16.08	10.65	10.75
05/01/95	1030	522.0	NA	14.98	13.05	16.34	16.05	10.71	10.78
05/02/95	945	518.6	3.25	15.41	13.14	16.47	16.05	10.80	10.85
05/03/95	900	518.4	NA	15.68	13.25	16.52	16.04	10.84	10.89
05/04/95	930	518.3	3.10	15.72	13.40	16.01	16.06	10.87	11.93
05/05/95	930	518.3	3.09	15.76	13.49	16.72	16.06	10.87	11.98
06/01/95	1016	518.6	3.24	17.00	14.24	17.08	16.02	11.11	11.15
07/07/95	1320	515.5	2.01	17.75	14.48	17.76	16.04	11.64	20.67
08/01/95	1100	515.9	2.25	18.05	14.70	17.88	16.09	11.67	11.68
08/31/95	1000	515.1	1.56	18.15	14.59	18.10	16.18	11.89	11.91
10/02/95	1000	515.3	1.85	18.13	14.59	18.08	16.18	11.88	11.90
10/30/95	845	538.8	5.09	16.17	14.69	16.88	16.35	10.95	10.95
10/31/95	845	534.4	6.29	15.52	14.65	16.65	16.45	10.82	10.87
11/01/95	930	522.7	4.48	14.98	13.05	16.34	16.05	10.71	10.75
11/02/95	1000	520.6	4.04	16.77	14.50	16.84	16.23	10.92	10.94
11/03/95	930	526.0	4.56	15.72	14.15	16.50	16.34	10.74	10.75
11/04/95	1130	524.5	4.91	15.78	14.08	16.50	16.30	10.78	10.76
11/05/95	1230	523.8	4.69	15.82	14.10	16.50	16.38	10.74	10.76
11/06/95	930	521.4	4.22	15.83	14.09	16.53	16.40	10.74	10.78
11/07/95	830	520.3	3.98	15.88	13.98	16.50	16.32	10.72	10.75
11/08/95	830	520.4	3.94	15.88	13.75	16.48	16.18	10.71	10.73
11/09/95	900	523.2	4.16	16.02	13.92	16.58	16.30	10.76	10.79
11/10/95	1330	522.6	4.14	16.06	14.06	16.55	16.45	10.76	10.80
11/11/95	945	520.9	3.89	16.06	13.90	17.57	16.41	11.76	10.79
11/12/95	900	521.4	4.06	15.94	13.65	16.47	16.17	10.72	10.72
11/13/95	1400	530.6	5.28	15.88	14.95	16.48	16.38	10.60	11.73

TABLE 2 - PIEZOMETER DEPTH READINGS
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				DEPTH READINGS, METERS					
DATE	TIME	POOL ELEV.	Tailwater Stage	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
11/14/95	1000	534.1	3.88	15.19	13.98	16.39	16.40	10.68	10.70
11/15/95	1130	539.8	4.01	13.62	13.60	15.94	16.20	10.60	10.58
11/16/95	930	538.0	5.83	13.83	13.67	16.02	16.30	10.53	10.60
11/17/95	930	538.7	6.04	14.71	13.58	16.24	16.32	10.60	10.66
11/18/95	1100	524.3	5.05	15.29	14.58	16.32	16.39	10.60	10.63
11/19/95	1115	516.2	4.58	15.40	13.48	16.33	16.35 PI		PI
11/20/95	930	523.7	4.35	15.82	14.10	16.50	16.38	10.74	10.76
11/21/95	930	522.0	4.19	14.97	13.03	16.32	16.02	10.72	10.74
11/22/95	930	522.2	4.12	15.03	13.10	16.32	16.03	10.71	10.74
12/04/95	1130	519.3	3.41	16.78	13.95	17.00	16.18	11.10	11.15
01/23/96	945	538.1	5.53	20.90	14.45	16.66	16.25	10.80	10.82
01/24/96	NA	533.1	5.62	14.71	13.58	16.26	16.35	10.62	10.68
01/25/96	900	531.9	4.50	14.68	13.55	16.22	16.31	10.60	10.65
01/26/96	900	528.4	4.48	15.92	14.10	16.50	16.28	10.70	10.71
01/27/96	800	524.9	4.83	15.82	14.12	16.48	16.38	10.72	10.76
01/28/96	830	533.4	4.61	14.71	13.58	16.29	16.32	10.65	10.65
01/29/96	800	534.6	6.39	14.20	13.80	16.05	16.10	10.49	10.53
01/31/96	915	539.8	6.39	13.53	13.98	16.92	16.15	10.45	10.52
02/01/96	1030	522.8	4.78	14.95	13.04	16.33	16.03	10.75	10.76
02/02/96	900	520.9	4.45	15.10	13.24	16.48	16.20	10.88	10.89
02/03/96	930	521.5	4.01	15.68	13.82	16.38	16.19	10.62	10.65
02/04/96	730	520.6	3.85	15.80	13.89	16.44	16.23	10.68	10.69
02/05/96	930	519.5	3.64	15.85	13.91	16.47	16.32	10.72	10.74
02/06/96	930	519.0	3.50	15.87	13.91	16.48	16.35	10.75	10.76
02/07/96	900	518.9	3.45	15.88	13.92	16.50	16.35	10.75	10.76
02/08/96	930	518.9	3.50	15.89	13.93	16.51	16.37	10.76	10.76
02/09/96	930	518.8	3.44	15.89	13.92	16.50	16.36	10.75	10.76
04/18/96	1130	548.0	2.55	11.28	13.62	15.32	15.85	10.25	10.35
04/19/96	1230	550.0	5.05	10.69	13.20	15.12	15.72	10.15	10.26
04/20/96	1000	549.3	NA	10.75	12.74	15.09	15.74	10.13	10.25
04/21/96	1115	549.0	4.50	10.82	12.34	15.11	15.80	10.12	10.25
04/22/96	1030	548.7	5.84	10.85	12.20	15.15	15.50	10.22	10.26
04/23/96	1030	547.6	6.55	11.02	11.87	15.14	15.76	10.14	10.26
04/24/96	1130	547.4	6.54	10.86	12.22	15.16	15.76	10.22	10.28
04/25/96	900	543.9	7.08	10.86	12.22	15.14	15.77	10.20	10.26
04/26/96	1145	547.2	7.08	11.16	11.55	15.15	15.65	10.13	10.26
04/27/96	1000	545.9	5.25	11.17	11.58	15.19	15.69	10.15	10.29
04/28/96	1030	545.2	5.32	11.19	15.61	15.19	15.71	10.16	10.31
04/29/96	1015	542.3	7.01	12.25	11.81	15.46	15.81	10.22	10.24
04/30/96	900	540.1	6.05	12.55	12.38	15.89	16.10	10.56	10.65
05/01/96	1030	536.0	NA	13.81	11.90	15.85	15.80	10.38	10.45
05/02/96	900	541.0	2.76	12.61	12.40	15.86	16.12	10.57	10.66
05/02/96	1100	539.6	6.82	13.25	12.20	15.74	15.80	10.35	10.42
05/03/96	1100	539.6	6.82	13.25	12.20	15.74	15.80	10.35	10.42
05/04/96	1000	533.3	6.43	14.35	12.20	15.98	15.85	10.42	10.48
05/05/96	1000	524.1	5.12	15.16	12.36	16.15	15.88	10.50	10.54
05/06/96	900	523.3	5.08	15.17	12.37	16.16	15.89	10.53	10.57
05/07/96	845	523.3	4.93	15.41	12.76	16.25	15.98	10.56	10.61
05/08/96	900	523.1	4.71	15.42	12.77	16.25	15.98	10.56	10.62
05/09/96	900	521.9	4.49	15.44	12.79	16.28	15.98	10.58	10.63
05/10/96	930	521.5	4.34	15.44	12.81	16.29	15.99	10.59	10.64
05/13/96	930	536.8	6.49	14.62	13.00	16.10	15.77	10.50	10.55

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DATE	TIME	POOL ELEV.	Tailwater Stage	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
05/14/96	900	542.0	5.44	12.98	13.08	15.72	15.87	10.36	10.45
05/15/96	930	540.1	6.26	13.05	12.95	15.70	15.80	10.33	10.42
05/16/96	930	535.1	6.52	15.18	13.96	16.36	16.37	10.68	10.70
05/17/96	1245	523.1	4.88	15.42	12.78	16.30	15.98	10.56	10.65
05/18/96	1100	523.0	4.76	15.43	12.80	16.32	15.98	10.58	10.66
05/19/96	1530	522.4	5.03	15.35	12.71	16.18	15.80	10.52	10.56
05/20/96	1000	522.2	4.55	15.41	12.70	16.22	15.70	10.54	10.58
05/21/96	1030	521.7	4.41	15.51	12.76	16.28	15.77	10.57	10.62
05/22/96	1000	521.1	4.21	15.61	12.88	16.34	15.85	10.63	10.69
05/23/96	900	520.1	2.76	15.65	12.91	16.38	15.89	10.69	10.75
06/13/96	900	518.5	NA	15.90	13.94	16.52	16.40	10.78	10.79
07/02/96	905	517.2	2.68	17.30	14.00	17.30	15.90	11.20	11.20
07/31/96	1050	517.5	2.88	17.00	14.10	17.10	15.90	11.10	11.10
08/28/96	1030	516.0	2.00	17.81	14.43	16.03	11.62	11.63	11.70
10/01/96	900	516.0	2.13	18.24	14.77	18.19	16.17	11.97	11.97
10/22/96	1000	544.1	4.00	15.88	14.68	17.10	16.05	11.22	11.17
10/23/96	1030	548.0	4.15	14.22	13.75	16.44	16.02	10.91	10.91
10/24/96	930	550.0	4.14	12.31	13.40	15.84	15.94	10.62	10.70
10/25/96	830	549.0	5.77	12.29	13.38	15.83	15.92	10.60	10.68
10/26/96	1030	546.8	7.02	11.52	13.12	15.57	16.08	10.50	10.58
10/27/96	1030	543.4	6.87	12.95	12.95	15.65	16.10	10.50	10.59
10/28/96	900	540.0	6.68	12.97	12.97	15.68	16.13	10.53	10.61
10/29/96	1430	525.3	4.20	15.78	14.06	16.48	16.30	10.76	10.75
10/30/96	1000	520.8	3.80	15.92	13.96	16.54	16.42	10.80	10.82
10/31/96	830	519.2	3.61	15.94	13.98	16.56	16.44	10.81	10.82
11/01/96	1345	519.7	3.63	15.95	13.98	16.56	16.45	10.81	10.82
01/06/97	1000	521.2	4.05	15.90	13.94	16.52	16.41	10.76	10.72
02/07/97	1300	517.9	2.92	17.58	14.43	17.26	16.34	11.62	11.62
03/20/97	930	518.4	3.24	15.91	13.95	16.53	16.39	10.78	10.77
04/09/97	1000	537.7	5.61	13.83	13.67	16.04	14.29	10.52	10.62
04/10/97	1115	533.1	6.21	14.64	13.91	16.32	15.89	10.75	10.80
04/11/97	1330	533.2	5.07	14.74	14.84	16.36	15.92	10.78	10.83
04/12/97	1130	530.4	4.91	15.03	14.77	10.41	15.92	16.84	10.85
04/13/97	1100	532.8	4.50	14.95	13.54	16.35	15.75	10.76	10.78
04/14/97	1100	534.2	4.55	14.91	13.62	16.40	15.81	11.81	10.85
04/15/97	800	535.0	4.59	14.66	13.70	16.38	15.92	10.81	10.85
04/16/97	1100	537.2	4.64	14.12	13.38	16.18	15.79	10.69	10.74
04/17/97	1115	536.0	5.66	14.16	13.40	16.20	15.80	10.70	10.75
04/18/97	1030	525.2	5.22	15.55	14.02	16.38	16.21	10.73	10.76
04/19/97	1315	538.3	4.68	14.18	13.23	16.16	15.75	10.66	10.69
04/20/97	1300	545.0	4.81	12.35	13.29	15.71	15.78	10.51	10.56
04/21/97	1115	548.0	4.81	11.38	13.13	15.42	15.78	10.45	10.46
04/22/97	1100	547.3	6.50	11.40	13.14	15.43	15.78	10.44	10.45
04/24/97	1030	545.0	6.21	11.48	13.19	15.49	15.83	10.49	10.51
04/25/97	1000	542.7	6.65	12.39	12.25	15.62	15.79	10.43	10.51
04/26/97	1010	540.0	5.20	13.09	12.30	15.82	15.83	10.50	10.58
04/27/97	1100	539.0	5.20	13.45	12.78	15.92	15.92	10.56	10.64
04/28/97	930	536.3	5.44	13.88	12.35	16.03	12.92	10.56	10.63
04/29/97	1000	525.4	5.22	15.00	12.40	16.25	15.95	10.66	10.70
04/30/97	1315	527.7	5.22	15.27	12.58	16.35	16.08	10.75	10.78

TABLE 2 - PIEZOMETER DEPTH READINGS
Instrumentation Appendix Report
Blackwater Dam

DATE	TIME	POOL ELEV.	Tailwater Stage	DEPTH READINGS, METERS PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B

CODES:
PD= Piezometer Dry
PI=Piezometer Inaccessible
PF=Piezometer Frozen
NA=Information not Given

TABLE 3 - ACTUAL PIEZOMETER WATER ELEVATION NGVD
Instrumentation Appendix Report
Blackwater Dam

		POREWATER ELEVATION, FEET-NGVD					
DATE	POOL EL.	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
10/12/94	516.3	524.26	535.59	528.15	533.53	528.36	528.36
11/03/94	516.8	523.87	536.15	527.79	533.93	528.10	528.16
12/02/94	518.4	523.58	535.75	527.56	533.44	528.07	528.16
12/30/94	531.5	529.78	536.18	531.96	533.27	531.15	531.11
12/31/94	519.4	530.66	536.38	532.22	533.17	531.28	531.21
01/01/95	521.2	530.96	537.16	532.51	533.60	531.38	531.31
01/02/95	521.3	530.60	537.49	532.38	533.90	531.28	531.18
01/03/95	521.0	530.70	537.56	532.32	533.96	531.38	531.15
02/01/95	519.0	528.63	537.98	531.50	534.26	530.82	530.72
03/06/95	517.7	526.10	536.47	530.68	533.70	530.63	530.69
04/03/95	520.0	528.63	536.24	532.09	534.09	531.41	531.38
04/14/95	536.4	535.62	537.69	533.43	534.65	531.94	531.74
04/15/95	537.4	536.93	537.82	533.92	534.68	531.99	531.93
04/16/95	538.1	537.91	538.08	534.19	534.68	532.17	532.03
04/17/95	539.0	538.57	538.15	534.35	534.42	532.27	532.03
04/18/95	539.3	538.70	538.18	534.45	534.58	532.40	532.16
04/20/95	540.0	539.68	539.46	534.78	534.75	532.59	532.52
04/21/95	539.6	539.62	539.30	534.74	534.58	532.46	532.23
04/22/95	540.0	539.68	539.52	534.78	534.68	532.53	532.33
04/23/95	540.1	539.62	539.46	534.74	534.65	532.59	532.33
04/24/95	540.1	540.11	540.61	535.14	534.68	532.73	532.49
04/25/95	539.8	540.11	540.74	535.01	534.72	532.65	532.46
04/26/95	539.0	539.98	540.64	535.17	534.58	532.59	532.33
04/27/95	538.6	539.91	540.57	535.04	534.45	532.46	532.23
04/28/95	539.0	539.98	540.64	535.17	534.58	532.59	532.33
04/29/95	538.4	539.91	540.57	535.04	534.45	532.43	532.20
04/30/95	535.6	537.42	540.87	534.29	534.58	532.30	532.03
05/01/95	522.0	534.53	540.94	533.66	534.68	532.10	531.93
05/02/95	518.6	533.12	540.64	533.24	534.68	531.81	531.70
05/03/95	518.4	532.24	540.28	533.07	534.72	531.68	531.57
05/04/95	518.3	532.11	539.79	534.74	534.65	531.58	528.16
05/05/95	518.3	531.97	539.49	532.42	534.65	531.58	528.00
06/01/95	518.6	527.91	537.03	531.23	534.78	530.79	530.72
07/07/95	515.5	525.45	536.24	529.00	534.72	529.05	499.49
08/01/95	515.9	524.46	535.52	528.61	534.55	528.95	528.98
08/31/95	515.1	524.13	535.88	527.89	534.26	528.23	528.23
10/02/95	515.3	524.20	535.88	527.95	534.26	528.26	528.26
10/30/95	538.8	530.63	535.56	531.89	533.70	531.32	531.38
10/31/95	534.4	532.76	535.69	532.64	533.37	531.74	531.64

TABLE 3 - ACTUAL PIEZOMETER WATER ELEVATION NGVD
Instrumentation Appendix Report
Blackwater Dam

		POREWATER ELEVATION, FEET-NGVD					
DATE	POOL EL.	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
11/01/95	522.7	534.53	540.94	533.66	534.68	532.10	532.03
11/02/95	520.6	528.66	536.18	532.02	534.09	531.41	531.41
11/03/95	526.0	532.11	537.33	533.14	533.73	532.00	532.03
11/04/95	524.5	531.91	537.56	533.14	533.86	531.87	532.00
11/05/95	523.8	531.78	537.49	533.14	533.60	532.00	532.00
11/06/95	521.4	531.74	537.52	533.04	533.53	532.00	531.93
11/07/95	520.3	531.58	537.88	533.14	533.80	532.07	532.03
11/08/95	520.4	531.58	538.64	533.20	534.26	532.10	532.10
11/09/95	523.2	531.12	538.08	532.87	533.86	531.94	531.90
11/10/95	522.6	530.99	537.62	532.97	533.37	531.94	531.87
11/11/95	520.9	530.99	538.15	529.63	533.50	528.66	531.90
11/12/95	521.4	531.38	538.97	533.24	534.29	532.07	532.13
11/13/95	530.6	531.58	534.70	533.20	533.60	532.46	528.82
11/14/95	534.1	533.84	537.88	533.50	533.53	532.20	532.20
11/15/95	539.8	539.00	539.13	534.97	534.19	532.46	532.59
11/16/95	538.0	538.31	538.90	534.71	533.86	532.69	532.52
11/17/95	538.7	535.42	539.20	533.99	533.80	532.46	532.33
11/18/95	524.3	533.52	535.92	533.73	533.57	532.46	532.43
11/19/95	516.2	533.16	539.52	533.69	533.70 PI	PI	
11/20/95	523.7	531.78	537.49	533.14	533.60	532.00	532.00
11/21/95	522.0	534.57	541.00	533.73	534.78	532.07	532.06
11/22/95	522.2	534.37	540.77	533.73	534.75	532.10	532.06
12/04/95	519.3	528.63	537.98	531.50	534.26	530.82	530.72
01/23/96	538.1	515.11	536.34	532.61	534.03	531.81	531.80
01/24/96	533.1	535.42	539.20	533.92	533.70	532.40	532.26
01/25/96	531.9	535.52	539.30	534.06	533.83	532.46	532.36
01/26/96	528.4	531.45	537.49	533.14	533.93	532.14	532.16
01/27/96	524.9	531.78	537.43	533.20	533.60	532.07	532.00
01/28/96	533.4	535.42	539.20	533.83	533.80	532.30	532.36
01/29/96	534.6	537.09	538.47	534.61	534.52	532.82	532.75
01/31/96	539.8	539.29	537.88	531.76	534.36	532.96	532.79
02/01/96	522.8	534.63	540.97	533.69	534.75	531.97	532.00
02/02/96	520.9	534.14	540.31	533.20	534.19	531.54	531.57
02/03/96	521.5	532.24	538.41	533.53	534.22	532.40	532.36
02/04/96	520.6	531.84	538.18	533.33	534.09	532.20	532.23
02/05/96	519.5	531.68	538.11	533.24	533.80	532.07	532.06
02/06/96	519.0	531.61	538.11	533.20	533.70	531.97	532.00
02/07/96	518.9	531.58	538.08	533.14	533.70	531.97	532.00
02/08/96	518.9	531.55	538.05	533.10	533.63	531.94	532.00

TABLE 3 - ACTUAL PIEZOMETER WATER ELEVATION NGVD
Instrumentation Appendix Report
Blackwater Dam

		POREWATER ELEVATION, FEET-NGVD					
DATE	POOL EL.	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
02/09/96	518.8	531.55	538.08	533.14	533.67	531.97	532.00
04/18/96	548.0	546.67	539.07	537.01	535.34	533.61	533.34
04/19/96	550.0	548.61	540.44	537.66	535.77	533.94	533.64
04/20/96	549.3	548.41	541.95	537.76	535.70	534.01	533.67
04/21/96	549.0	548.18	543.26	537.70	535.50	534.04	533.67
04/22/96	548.7	548.08	543.72	537.57	536.49	533.71	533.64
04/23/96	547.6	547.53	544.81	537.60	535.63	533.97	533.64
04/24/96	547.4	548.05	543.66	537.53	535.63	533.71	533.57
04/25/96	543.9	548.05	543.66	537.60	535.60	533.78	533.64
04/26/96	547.2	547.07	545.86	537.57	536.00	534.01	533.64
04/27/96	545.9	547.03	545.76	537.43	535.86	533.94	533.54
04/28/96	545.2	546.97	532.54	537.43	535.80	533.91	533.47
04/29/96	542.3	543.49	545.00	536.55	535.47	533.73	533.72
04/30/96	540.1	542.51	543.13	535.14	534.52	532.59	532.36
05/01/96	536.0	538.37	544.71	535.27	535.50	533.19	533.02
05/02/96	541.0	542.31	543.07	535.24	534.45	532.56	532.33
05/02/96	539.6	540.21	543.72	535.63	535.50	533.28	533.11
05/03/96	539.6	540.21	543.72	535.63	535.50	533.28	533.11
05/04/96	533.3	536.60	543.72	534.84	535.34	533.05	532.92
05/05/96	524.1	533.94	543.20	534.29	535.24	532.79	532.72
05/06/96	523.3	533.91	543.17	534.25	535.21	532.69	532.62
05/07/96	523.3	533.12	541.89	533.96	534.91	532.59	532.49
05/08/96	523.1	533.09	541.85	533.96	534.91	532.59	532.46
05/09/96	521.9	533.02	541.79	533.86	534.91	532.53	532.43
05/10/96	521.5	533.02	541.72	533.83	534.88	532.50	532.39
05/13/96	536.8	535.71	541.10	534.45	535.60	532.79	532.69
05/14/96	542.0	541.10	540.84	535.70	535.27	533.25	533.02
05/15/96	540.1	540.87	541.26	535.76	535.50	533.35	533.11
05/16/96	535.1	533.88	537.95	533.60	533.63	532.20	532.20
05/17/96	523.1	533.09	541.82	533.79	534.91	532.59	532.36
05/18/96	523.0	533.06	541.76	533.73	534.91	532.53	532.33
05/19/96	522.4	533.32	542.05	534.19	535.50	532.73	532.65
05/20/96	522.2	533.12	542.08	534.06	535.83	532.66	532.59
05/21/96	521.7	532.79	541.89	533.86	535.60	532.56	532.46
05/22/96	521.1	532.47	541.49	533.66	535.34	532.37	532.23
05/23/96	520.1	532.34	541.39	533.53	535.21	532.17	532.03
06/13/96	518.5	531.52	538.02	533.07	533.53	531.87	531.90
07/02/96	517.2	526.92	537.82	530.51	535.18	530.50	530.56
07/31/96	517.5	527.91	537.49	531.17	535.18	530.82	530.88

TABLE 3 - ACTUAL PIEZOMETER WATER ELEVATION NGVD
Instrumentation Appendix Report
Blackwater Dam

		POREWATER ELEVATION, FEET-NGVD					
DATE	POOL EL.	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
08/28/96	516.0	525.25	536.41	534.68	549.22	529.08	528.91
10/01/96	516.0	523.84	535.29	527.59	534.29	527.97	528.03
10/22/96	544.1	531.58	535.59	531.17	534.68	530.43	530.65
10/23/96	548.0	537.03	538.64	533.33	534.78	531.45	531.51
10/24/96	550.0	543.29	539.79	535.30	535.04	532.40	532.20
10/25/96	549.0	543.36	539.85	535.33	535.11	532.46	532.26
10/26/96	546.8	545.89	540.71	536.19	534.58	532.79	532.59
10/27/96	543.4	541.19	541.26	535.93	534.52	532.79	532.56
10/28/96	540.0	541.13	541.20	535.83	534.42	532.69	532.49
10/29/96	525.3	531.91	537.62	533.20	533.86	531.94	532.03
10/30/96	520.8	531.45	537.95	533.01	533.47	531.81	531.80
10/31/96	519.2	531.38	537.88	532.94	533.40	531.77	531.80
11/01/96	519.7	531.35	537.88	532.94	533.37	531.77	531.80
01/06/97	521.2	531.52	538.02	533.07	533.50	531.94	532.13
02/07/97	517.9	526.00	536.41	530.64	533.73	529.12	529.18
03/20/97	518.4	531.48	537.98	533.04	533.57	531.87	531.97
04/09/97	537.7	538.31	538.90	534.65	540.46	532.73	532.46
04/10/97	533.1	535.65	538.11	533.73	535.21	531.97	531.87
04/11/97	533.2	535.32	535.06	533.60	535.11	531.87	531.77
04/12/97	530.4	534.37	535.29	553.12	535.11	511.99	531.70
04/13/97	532.8	534.63	539.33	533.63	535.67	531.94	531.93
04/14/97	534.2	534.76	539.07	533.46	535.47	528.49	531.70
04/15/97	535.0	535.58	538.80	533.53	535.11	531.77	531.70
04/16/97	537.2	537.36	539.85	534.19	535.54	532.17	532.06
04/17/97	536.0	537.22	539.79	534.12	535.50	532.14	532.03
04/18/97	525.2	532.66	537.75	533.53	534.16	532.04	532.00
04/19/97	538.3	537.16	540.35	534.25	535.67	532.27	532.23
04/20/97	545.0	543.16	540.15	535.73	535.57	532.76	532.65
04/21/97	548.0	546.34	540.67	536.68	535.57	532.96	532.98
04/22/97	547.3	546.28	540.64	536.65	535.57	532.99	533.02
04/24/97	545.0	546.02	540.48	536.45	535.40	532.82	532.82
04/25/97	542.7	543.03	543.56	536.02	535.54	533.02	532.82
04/26/97	540.0	540.73	543.40	535.37	535.40	532.79	532.59
04/27/97	539.0	539.55	541.82	535.04	535.11	532.59	532.39
04/28/97	536.3	538.14	543.23	534.68	544.95	532.59	532.43
04/29/97	525.4	534.47	543.07	533.96	535.01	532.27	532.20
04/30/97	527.7	533.58	542.48	533.63	534.58	531.97	531.93

TABLE 3 - ACTUAL PIEZOMETER WATER ELEVATION NGVD
Instrumentation Appendix Report
Blackwater Dam

		POREWATER ELEVATION, FEET-NGVD					
DATE	POOL EL.	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B

CODES:
PD= Piezometer Dry
PF=Piezometer Frozen
PI=Piezometer Inaccessible
NA=Information not Given

Table 4 - PIEZOMETER DATA USED TO CALCULATE AVERAGE WATER LEVELS FOR EACH PIEZOMETER
Instrumentation Appendix Report
Blackwater Dam

		POREWATER ELEVATION FOR NORMAL POOL, FT-NGVD					
DATE	POOL EL.	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3A	PZ-3B
12-Oct-94	516.3	524.26	535.59	528.15	533.53	528.36	528.36
03-Nov-94	516.8	523.87	536.15	527.79	533.93	528.10	528.16
02-Dec-94	518.4	523.58	535.75	527.56	533.44	528.07	528.16
03-Jan-95	521.0	530.70	537.56	532.32	533.96	531.38	531.15
01-Feb-95	519.0	528.63	537.98	531.50	534.26	530.82	530.72
06-Mar-95	517.7	526.10	536.47	530.68	533.70	530.63	530.69
03-Apr-95	520.0	528.63	536.24	532.09	534.09	531.41	531.38
05-May-95	518.3	531.97	539.49	532.42	534.65	531.58	528.00
01-Jun-95	518.6	527.91	537.03	531.23	534.78	530.79	530.72
07-Jul-95	515.5	525.45	536.24	529.00	534.72	529.05	499.49
01-Aug-95	515.9	524.46	535.52	528.61	534.55	528.95	528.98
31-Aug-95	515.1	524.13	535.88	527.89	534.26	528.23	528.23
02-Oct-95	515.3	524.20	535.88	527.95	534.26	528.26	528.26
22-Nov-95	522.2	534.37	540.77	533.73	534.75	532.10	532.06
04-Dec-95	519.3	528.63	537.98	531.50	534.26	530.82	530.72
09-Feb-96	518.8	531.55	538.08	533.14	533.67	531.97	532.00
10-May-96	521.5	533.02	541.72	533.83	534.88	532.50	532.39
23-May-96	520.1	532.34	541.39	533.53	535.21	532.17	532.03
13-Jun-96	518.5	531.52	538.02	533.07	533.53	531.87	531.90
02-Jul-96	517.2	526.92	537.82	530.51	535.18	530.50	530.56
31-Jul-96	517.5	527.91	537.49	531.17	535.18	530.82	530.88
28-Aug-96	516.0	525.25	536.41	534.68	549.22	529.08	528.91
01-Oct-96	516.0	523.84	535.29	527.59	534.29	527.97	528.03
01-Nov-96	519.7	531.35	537.88	532.94	533.37	531.77	531.80
06-Jan-97	521.2	531.52	538.02	533.07	533.50	531.94	532.13
07-Feb-97	517.9	526.00	536.41	530.64	533.73	529.12	529.18
20-Mar-97	518.4	531.48	537.98	533.04	533.57	531.87	531.97
30-Apr-97	527.7	533.58	542.48	533.63	534.58	531.97	531.93
Average Water level	518.57	528.33	537.63	531.19	534.75	530.43	529.24

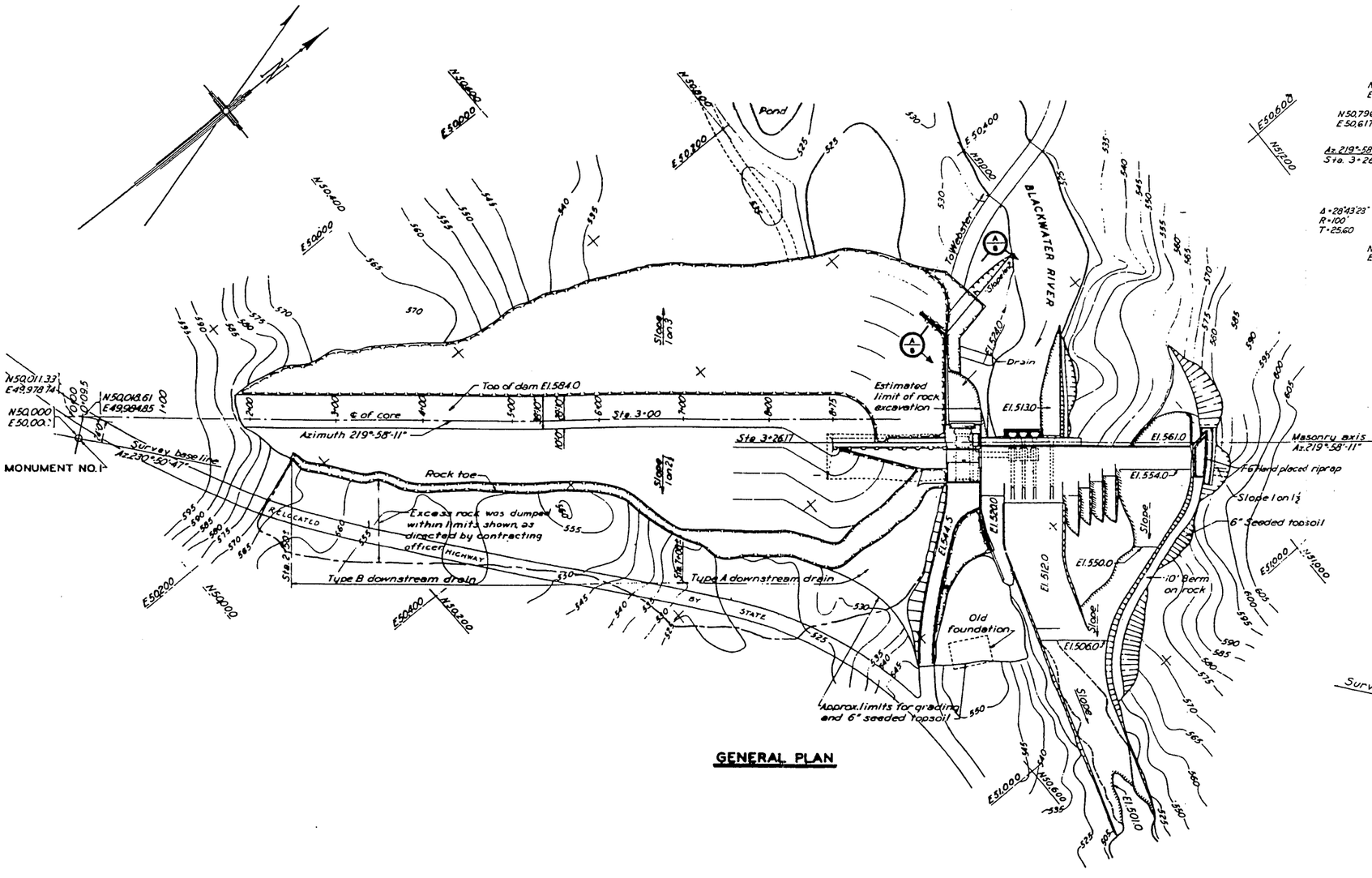
TABLE 5 - PREDICTED PIEZOMETER WATER ELEVATIONS
Instrumentation Appendix
Blackwater Dam, Webster, New Hampshire

Piezometer	Projected Piezometer Elevation for Reservoir at El. 566
PZ-1A	561.3
PZ-1B	*
PZ-2A	541.3
PZ-2B	536.1
PZ-3A	534
PZ-3B	534

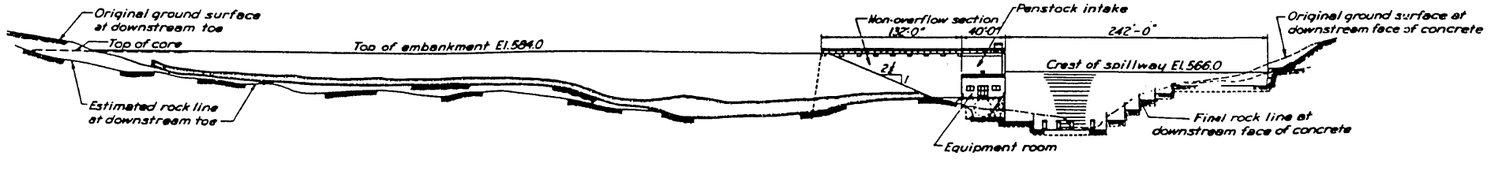
* No projection for PZ-1B due to scatter of data.

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



GENERAL PLAN



DOWNSTREAM ELEVATION

General Notes:
Elevations conform with U.S.G.S. datum
Limits of type A and B downstream drains are tentative, definite limits to be determined by contracting officer in field.

RECORD DRAWINGS

NO.	CHARACTER OF REVISIONS	DATE	BY
6	Final field changes.	11-6-45	J.N.G.
5	West approach waterdrain	4-30-41	J.N.G.
4	Deleted East approach Wall	4-24-41	J.N.G.
3	West Approach Wall	10-8-40	F.S.B.
2	Spillway channel	9-23-40	F.S.B.
1	Spillway abutment	7-1-40	F.S.B.

MERRIMACK VALLEY FLOOD CONTROL
BLACKWATER DAM
BLACKWATER RIVER

GENERAL PLAN AND ELEVATION

50' 0 50' 100'

U. S. ENGINEER OFFICE, BOSTON, MASS., MARCH, 1940

APPROVAL RECOMMENDED: [signature] CAPTAIN, CORPS OF ENGINEERS, U.S. ARMY, ENGINEERING OFFICER

APPROVED: W. D. Mummau, DISTRICT ENGINEER

SUBMITTED: John E. Allen, CHIEF FLOOD CONTROL

CHIEF FLOOD CONTROL [illegible]

PLATE 1

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

For limits of borrow area B and clearing see Sheet 6

LIMIT OF CONTRACTOR'S WORK AREA

LIMIT OF CLEARING BY GOVERNMENT

WASTE AREA

Pond

Temporary Wood Bridge 16'×78'

BLACKWATER RIVER

To Webster

12' Dirt Road to Contractor's Fill & Borrow Area A

Power 2W

Dirt Road

℄ of core

Old Foundation Tel. 2W

Old cellar

18' Bituminous Surfaced Road to Contractor's Borrow Area C

Spring

Chimney

SWETTS MILLS Old cellar

MONUMENT NO. 1

MONUMENT NO. 2

RIVER

General Notes:

Elevations conform with U.S.G.S. datum.
T denotes test pit, trench or auger boring.
D " drill hole.
Logs of drill holes 1 to 19 shown on Sheet 4; hole 29 on Sheet 5.
Geological profile shown on Sheet 5
Waste areas to be brought up to uniform elevations, the heights of lifts and definite limits of areas to be determined by the contracting officer.

RECORD DRAWINGS

MERRIMACK VALLEY FLOOD CONTROL
BLACKWATER DAM
BLACKWATER RIVER
PLAN OF FOUNDATION EXPLORATION

SCALE 50' 0 50' 100'

U. S. ENGINEER OFFICE, BOSTON, MASS., MARCH, 1940

APPROVED: RECOMMENDED: Captain Corps of Engineers, Local Unloading Div.

APPROVED: Chief of Engineers, U. S. Army

SUBMITTED: John E. Allen, Asst. Flood Control Division Engineer

CHIEF FLOOD CONTROL DIVISION: F. Stewart Brown, Engineer

DES. BY PJC; DR. BY JFR; TR. BY JFR; CK. BY PJC

1 Final field changes. 4-6-40

NO. CHANGES TO DATE BY

REVISIONS

FILE NO. M13-50/3

PLATE 2

D-1

0.0 EL. 330.7

Gravelly and Silty Sand. With Cobbles and Boulders in lower 5'

12.4 EL. 318.3

Variable, coarse Granite and Granitic Schist. Stained partings and small fractures very numerous above elev 523, occasional below. Poorly bonded shear zone from elev 512 to bottom. Core recovery 95%

37.4 EL. 293.3

D-2

0.0 EL. 536.8

Very fine to coarse Sand with some Gobbles.

5.8 EL. 532.4

Coarse Granitic Gneiss. Stained partings and very small fractures very numerous above elev 526, occasional below. Core recovery 91%.

30.0 EL. 507.4

D-3

0.0 EL. 543.7

1.4 EL. 542.3

Gravelly Sand.

Variable, coarse and fine grained Granitic Gneiss. Open fractures at elev 537.3, 535.6, 523.7, and 521.7. Stained partings and very small fractures very numerous above elev 535.6, occasional below. Core recovery 96%

71.3 EL. 472.2

D-4

0.0 EL. 522.3

0.3 EL. 522.0

Sand.

Variable, coarse and fine grained Granite and Granitic Gneiss. Stained partings and small fractures occasional throughout. Core recovery 97%

55.1 EL. 467.2

D-5

0.0 EL. 518.0

Variable, Granite and Granitic Gneiss. Badly fractured and seamy bedrock or loose rock. Core recovery 50%.

9.2 EL. 508.8

Variable, coarse Granite and Granitic Gneiss. Sheltered zone from elev 490.3 - 485.9, stained partings and small fractures occasional elsewhere. Core recovery 91%.

80.0 EL. 458.0

D-6

0.0 EL. 540.3

Cobbly and Bouldery Sand.

18.0 EL. 524.3

Variable, coarse and fine grained Granite and Granitic Gneiss. Occasional 1'-2' sand-filled or rotted fissures, and stained partings and small fractures throughout. Core recovery 87%

91.0 EL. 449.3

D-7

0.0 EL. 537.2

Cobbly and Bouldery Sand.

6.8 EL. 530.4

Variable, coarse Granite and Granitic Gneiss. Clayey 1' seam at elev 549.7 and 3' seam at 545.1. Stained partings and very small fractures numerous throughout. Core recovery 98%.

31.8 EL. 505.0

D-8

0.0 EL. 538.0

3.4 EL. 534.6

Gravelly and Silty Sand.

Coarse Granitic Gneiss. Stained partings and very small fractures numerous above elev 549.5, occasional below. Core recovery 88%.

29.4 EL. 508.6

D-9

0.0 EL. 389.6

3.4 EL. 386.2

Silty Sand with some Cobbles and Boulders.

Variable, coarse Granite and Granitic Gneiss. 4 tol fissures at elev 565.7, 563.6, 557.5, 554.9, 553.6, and 548.7. Stained partings and very small fractures numerous throughout. Core recovery 93%.

28.5 EL. 341.1

D-10

0.0 EL. 387.7

Silty Sand with Cobbles and Boulders.

7.2 EL. 380.5

Granitic Gneiss. Much fissured bedrock or loose rock. Core recovery 52%.

11.4 EL. 376.2

Coarse Granitic Gneiss. Stained partings and very small fractures numerous throughout. Core recovery 85%.

37.2 EL. 350.4

D-11

0.0 EL. 506.9

1.2 EL. 505.7

Gravelly and Cobbly Sand.

Variable, coarse Granite and Granitic Gneiss. Stained partings and very small fractures occasional throughout. Core recovery 98%.

31.2 EL. 437.7

D-12

0.0 EL. 561.0

5.7 EL. 555.3

Gravelly and Cobbly Sand.

Granitic Gneiss. Rotten seamy zone in bottom 4'. Stained partings and very small fractures occasional throughout. Core recovery 92%.

64.1 EL. 498.9

D-13

0.0 EL. 538.7

3.2 EL. 535.5

Sand.

Variable, Granite and Granitic Gneiss. 4' seam at elev 522. Stained partings and very small fractures occasional throughout. Core recovery 90%.

43.2 EL. 493.5

D-14

0.0 EL. 553.2

Sand, with Gravel and broken rock below elev 548.

10.1 EL. 543.1

Coarse Granitic Gneiss with coarse Granite veins. 2' seam at elev 513. Stained partings and very small fractures occasional throughout. Core recovery 98%

50.1 EL. 503.1

D-15

0.0 EL. 600.8

Silty Sand with Gravel and Cobbles.

17.4 EL. 583.5

Coarse Granitic Gneiss with coarse Granite veins. Small rotten seams at elev 583, 582, 578, 577.5, and from 573.5 to 572. Stained partings and very small fractures numerous above elev 572, absent below. Core recovery 90%.

37.4 EL. 563.5

D-16

0.0 EL. 553.0

Silty Sand with Gravel and Cobbles.

8.8 EL. 544.2

Weathered Bedrock fissure or Boulders.

12.8 EL. 540.2

Variable, coarse Granitic Gneiss and Granite. 1' seam at elev 535. Stained partings and very small fractures occasional throughout. Core recovery 88%.

37.0 EL. 516.0

D-17

0.0 EL. 330.9

Gravelly Sand.

5.8 EL. 325.1

Coarse Granitic Gneiss. Stained partings and very small fractures numerous throughout. Core recovery 92%

25.0 EL. 305.9

D-18

0.0 EL. 548.3

Bouldery and Gravelly Sand.

6.8 EL. 541.5

Coarse Granitic Gneiss. Rotted 1'-2' seams at elev. 531, 529.5, and 523. Stained partings and very small fractures occasional throughout. Core recovery 90%.

29.5 EL. 519.8

D-19

0.0 EL. 534.7

Bouldery and Gravelly Sand.

9.0 EL. 525.7

Variable, coarse Granitic Gneiss and Granite. 1' seams at elev 531.5 and 526.5. Stained partings and very small fractures numerous above elev. 541, occasional below. Core recovery 93%.

39.0 EL. 495.7

DEFINITION OF TERMS

SIZES	SYMBOL	DIAM.
MUCK		
CLAY		0.002 MM.
SILT, FINE		0.006 MM.
SILT, MEDIUM		0.02 MM.
SILT, COARSE		0.06 MM.
SAND FINE		0.2 MM.
SAND, MEDIUM		0.6 MM.
SAND, COARSE		2.0 MM.
GRAVEL, FINE		¼ INCHES
GRAVEL, MEDIUM		2 INCHES
GRAVEL, COARSE		4 INCHES
COBBLES		10 INCHES
BOULDERS		
GRANITE, COARSE		
GRANULAR MICA SCHIST OR MICACEOUS GNEISS		

DESCRIPTIVE TERMS

Slightly Silty etc. denotes 1% - 10% by weight of Silt etc.

Silty etc. denotes 10% - 20% by weight of Silt etc.

Very Silty etc. denotes 20% - 50% by weight of Silt etc.

General Notes:

Elevations conform with U.S.G.S. datum.

Overburden dry sampled; bedrock diamond drilled.

RECORD DRAWINGS

NO.	CHARACTER	DATE	BY
	REVISIONS		

MERRIMACK VALLEY FLOOD CONTROL
BLACKWATER DAM
BLACKWATER RIVER

RECORD OF FOUNDATION EXPLORATION NO. I.

SCALE: AS SHOWN

U. S. ENGINEER OFFICE, BOSTON, MASS., MARCH, 1940

APPROVAL RECOMMENDED: L. A. Gibson, CAPTAIN, CORPS OF ENGINEERS, CHIEF, ENGINEERING DIV.

APPROVED: A. R. Belgman, COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

SUBMITTED: John L. Alley, CHIEF FLOOD CONTROL DIVISION, BR. ENGINEER

CHIEF FLOOD CONTROL DIVISION: E. Howard Brown, ENGINEER

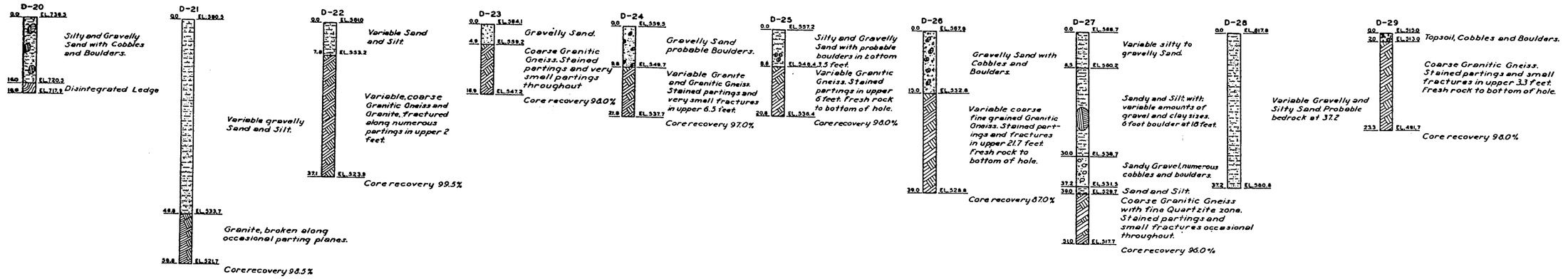
DES. BY A.J.H.
DR. BY A.J.H.
TR. BY J.F.H.
CK. BY A.J.H.

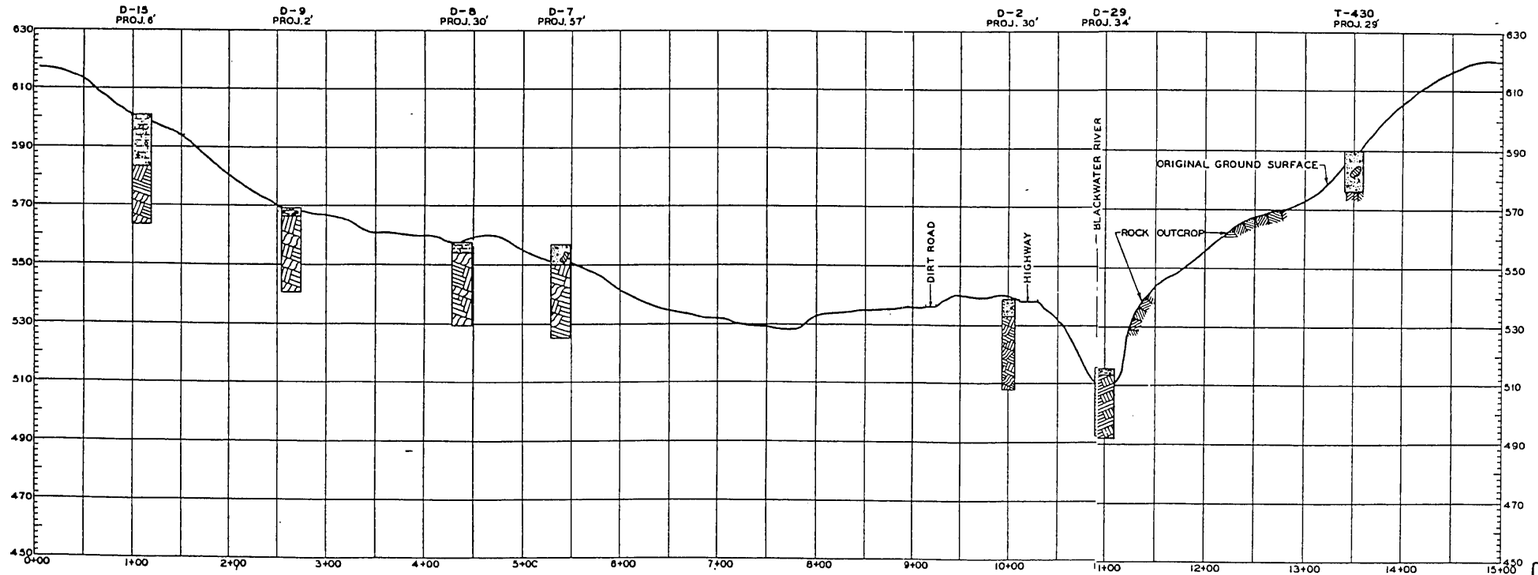
FILE NO. M13—50/4

PLATE 3

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY





PROFILE – LOOKING UPSTREAM
℄ OF EMBANKMENT STA. 0+00 TO STA. 8+75
℄ OF MASONRY AXIS STA. 8+75 TO STA. 15+00

General Notes:
Elevations conform with U.S.G.S. datum.
Overburden dry sampled; bedrock diamond drilled.

RECORD DRAWINGS

NO	CHARACTER REVISIONS	DATE	BY

MERRIMACK VALLEY FLOOD CONTROL
BLACKWATER DAM
BLACKWATER RIVER
RECORD OF FOUNDATION EXPLORATION NO. 2

SCALE AS SHOWN

U. S. ENGINEER OFFICE, BOSTON, MASS. MARCH, 1940

APPROVED AND RECOMMENDED: [signature] CAPTAIN CORPS OF ENGINEERS, CHIEF ENGINEERING DIV.

APPROVED: [signature] COLONEL CORPS OF ENGINEERS DISTRICT ENGINEER

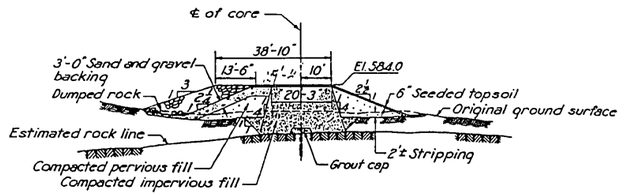
SUBMITTED: [signature] CHIEF FLOOD CONTROL DESIGN SECTION, ENGINEER

CHIEF FLOOD CONTROL DESIGN F. Stewart Brown ENGINEER

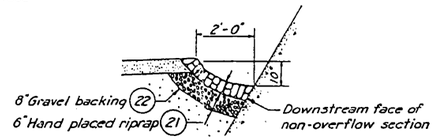
DES. BY R.W.H.
DR. BY G.A.P.
TR. BY W.H.
CH. BY P.J.H.

FILE NO. M13-50/5

PLATE 4

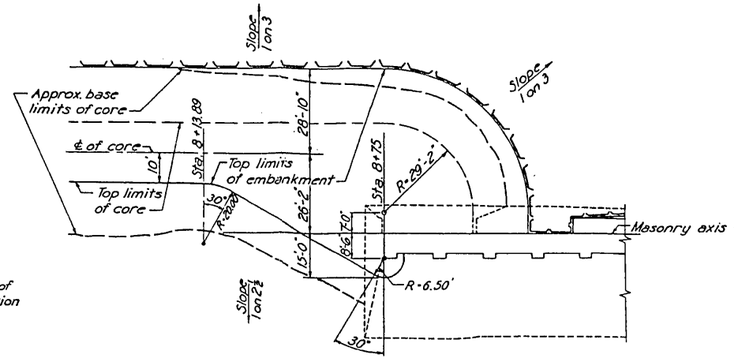


SECTION – STA. 2 + 25

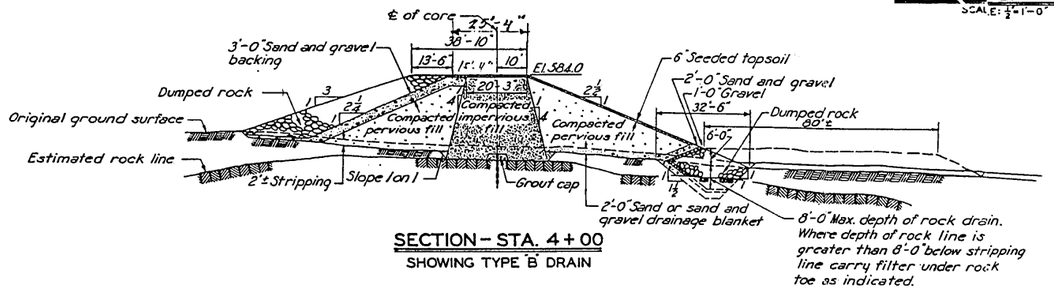


ROCK PAVED GUTTER

SCALE: ½"=1'-0"

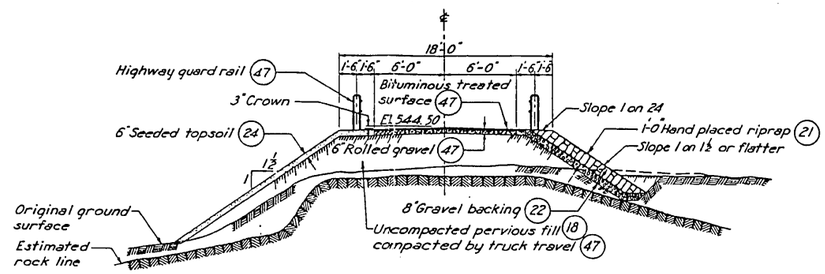


DETAIL OF EMBANKMENT TRANSITION



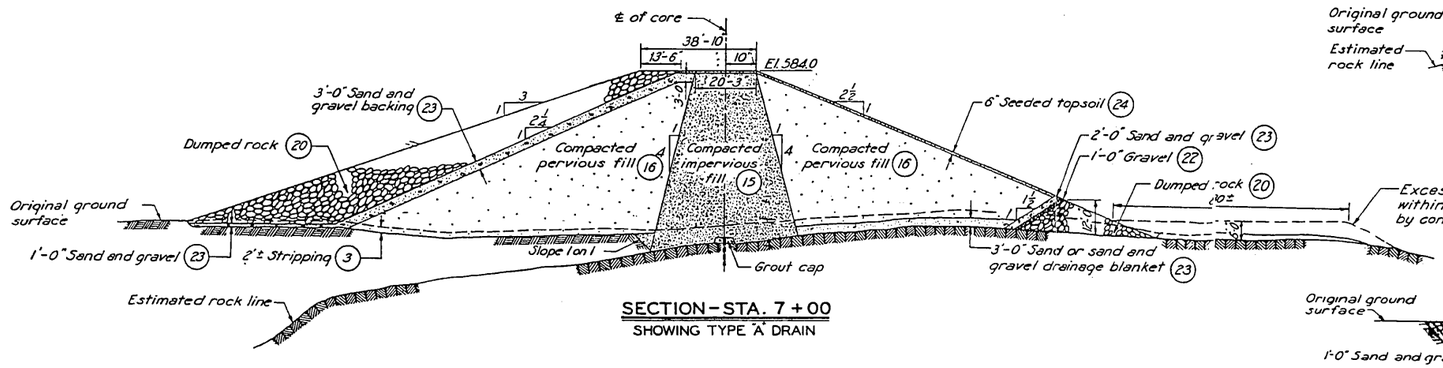
SECTION – STA. 4 + 00

SHOWING TYPE 'B' DRAIN



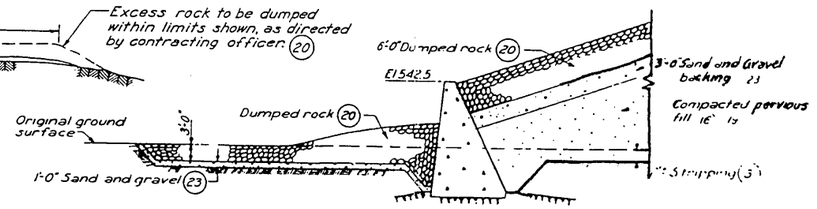
TYPICAL SECTION OF DRIVEWAY

SCALE: 1"=5'-0"



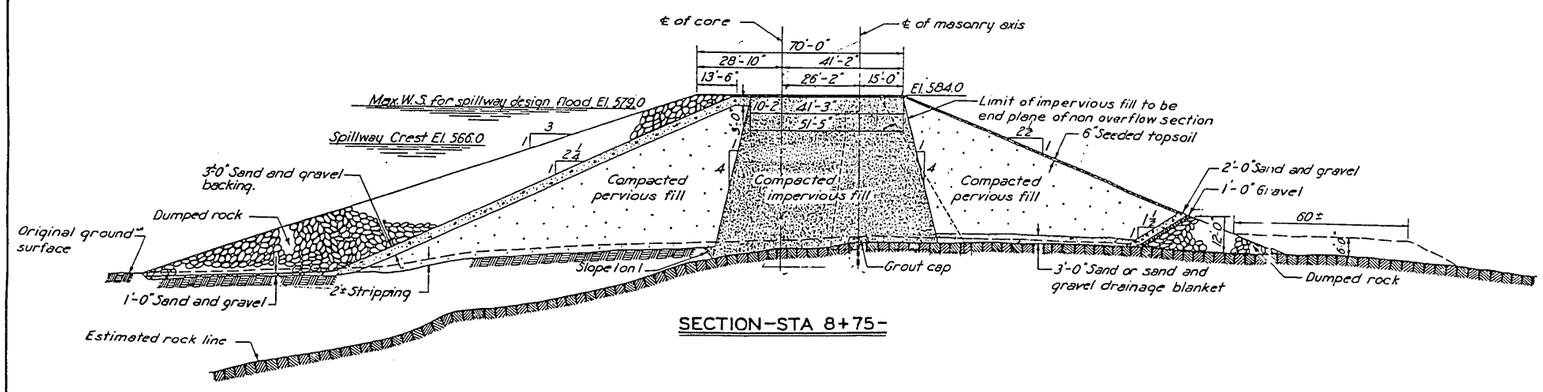
SECTION – STA. 7 + 00

SHOWING TYPE 'A' DRAIN



SECTION

SCALE: 1"=10'-0"



SECTION – STA 8+75 –

General Notes:

Figures in circles indicate item number under which payment will be made.

RECORD DRAWINGS

3	Final Field changes	J.W.M.N.G.	
2	Dumped rock Sec. 4/7	C.W.M.	U.S.E.
1	Section A/7		
NO.	CHARACTER OF REVISIONS	DATE	

MERRIMACK VALLEY FLOOD CONTROL

BLACKWATER DAM

BLACKWATER RIVER

EMBANKMENT SECTIONS

20' 0 20' 40'

U. S. ENGINEER OFFICE, BOSTON, MASS. MARCH, 1940

APPROVED/RECOMMENDED: [signature] CAPTAIN, CORPS OF ENGINEERS, CHIEF, ENGINEERING DIV.

APPROVED: [signature] COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

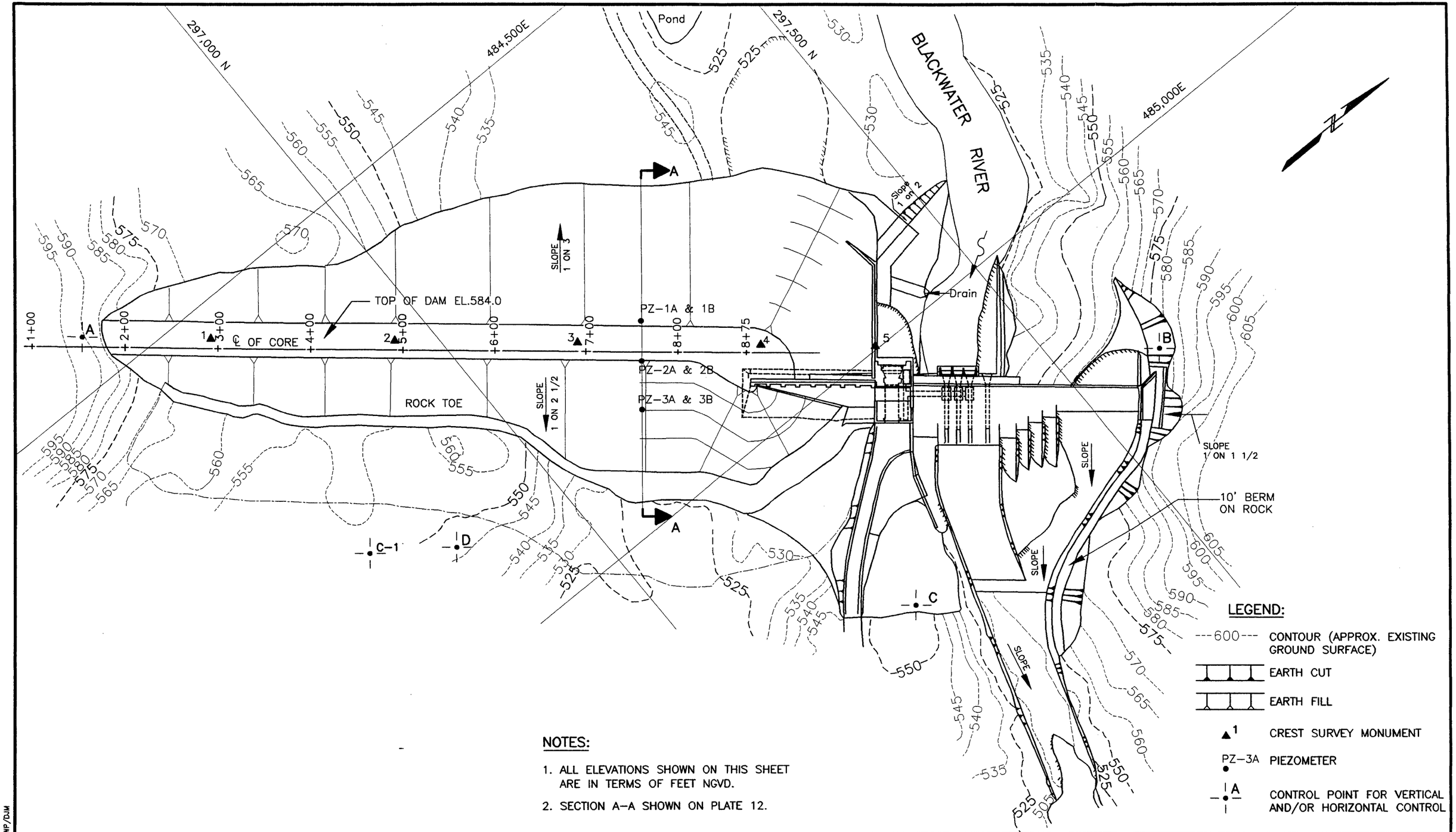
SUBMITTED: John E. Allen, CHIEF FLOOD CONTROL DIVISION, SR. ENGINEER

CHIEF FLOOD CONTROL DESIGN: F. Stuart Brown

DES. BY R.M.N. DR. BY C.W.S. TR. BY C.W.S. CK. BY J.O.L.

FILE NO. M13 – 51/3

PLATE 5



NOTES:

1. ALL ELEVATIONS SHOWN ON THIS SHEET ARE IN TERMS OF FEET NGVD.
2. SECTION A–A SHOWN ON PLATE 12.

0 100 200

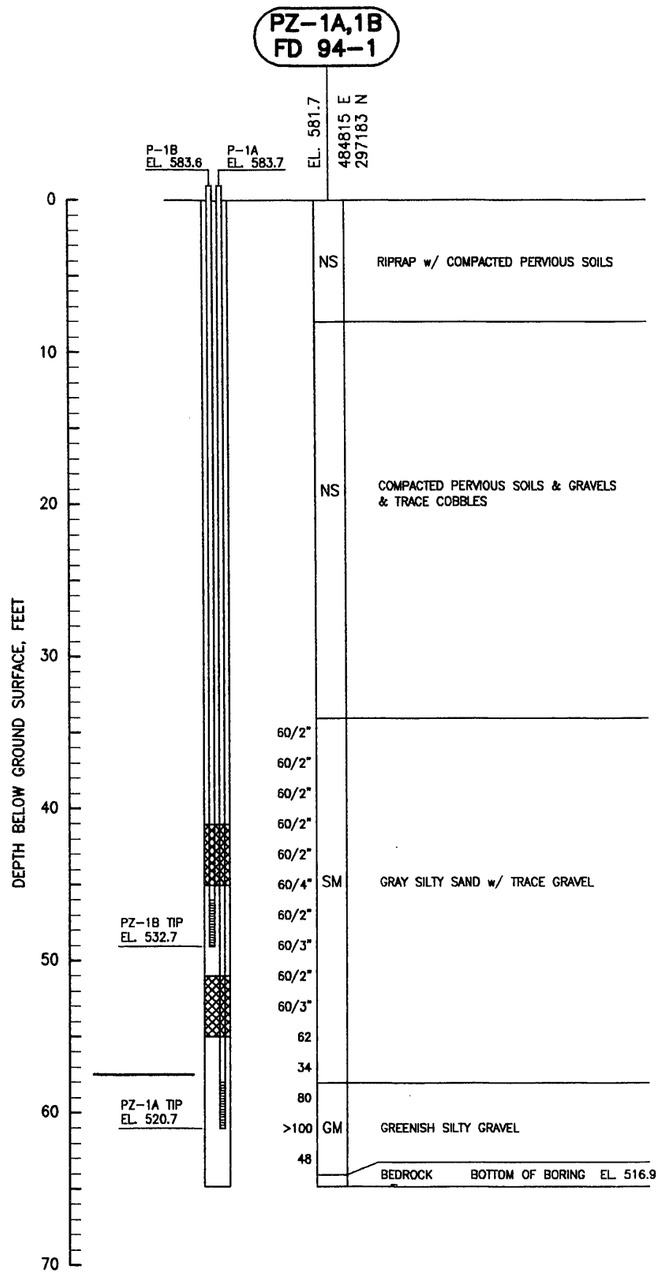
SCALE, FEET

LEGEND:

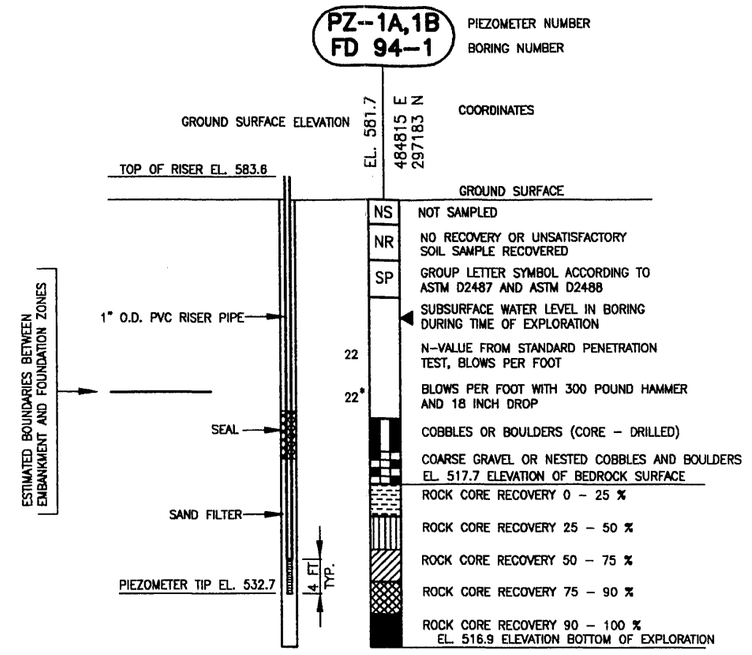
- ---600--- CONTOUR (APPROX. EXISTING GROUND SURFACE)
- EARTH CUT
- EARTH FILL
- ▲1 CREST SURVEY MONUMENT
- PZ–3A PIEZOMETER
- A CONTROL POINT FOR VERTICAL AND/OR HORIZONTAL CONTROL

U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	INSTRUMENTATION GENERAL PLAN
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 6

97494-01 9/24/97 PWP/DJM

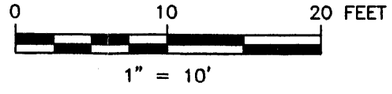


LEGEND FOR GRAPHIC LOG



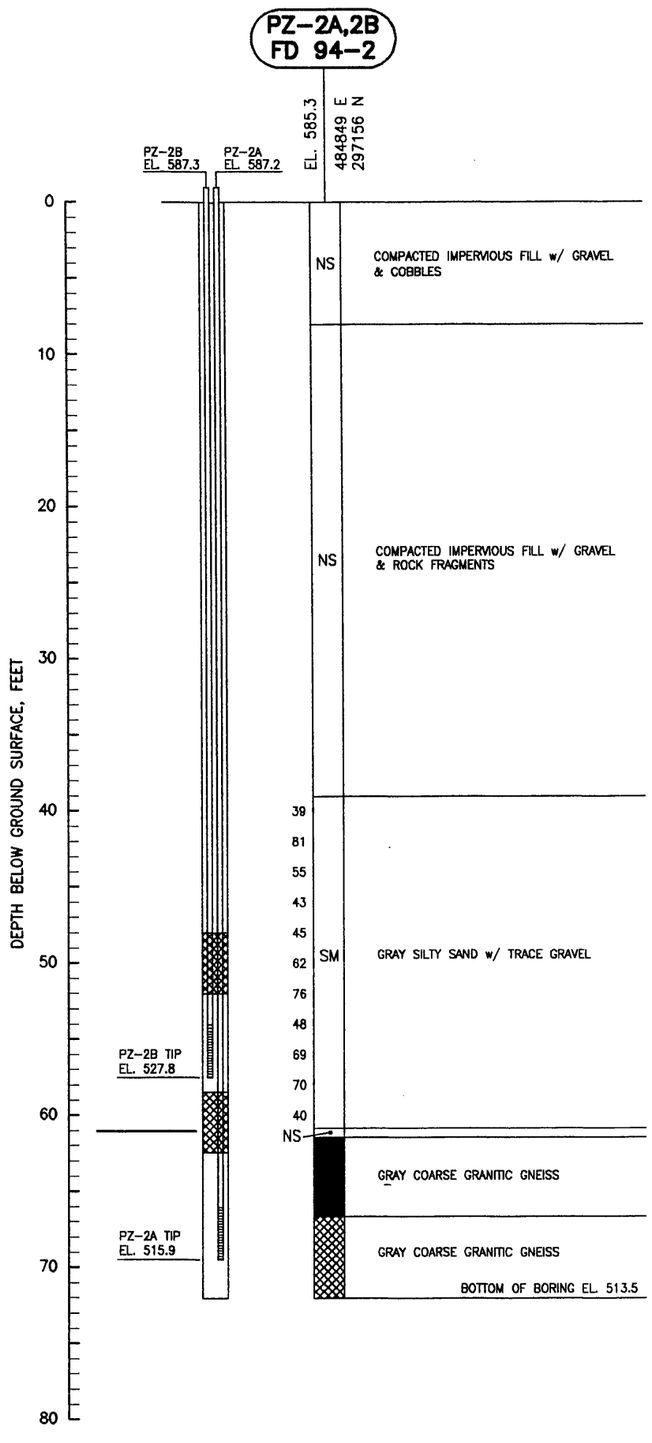
NOTES:

1. SEE PLATE 6 FOR BORING LOCATIONS.
2. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

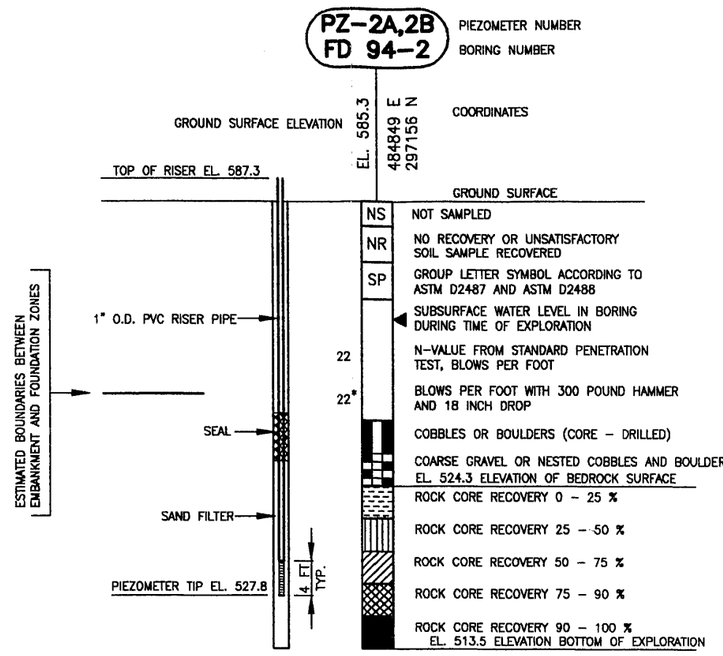


97494-04 10/28/97 DJM

U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	ENGINEERING LOGS FD94–1
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 7

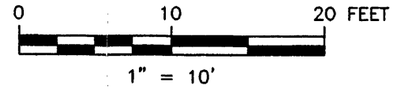


LEGEND FOR GRAPHIC LOG



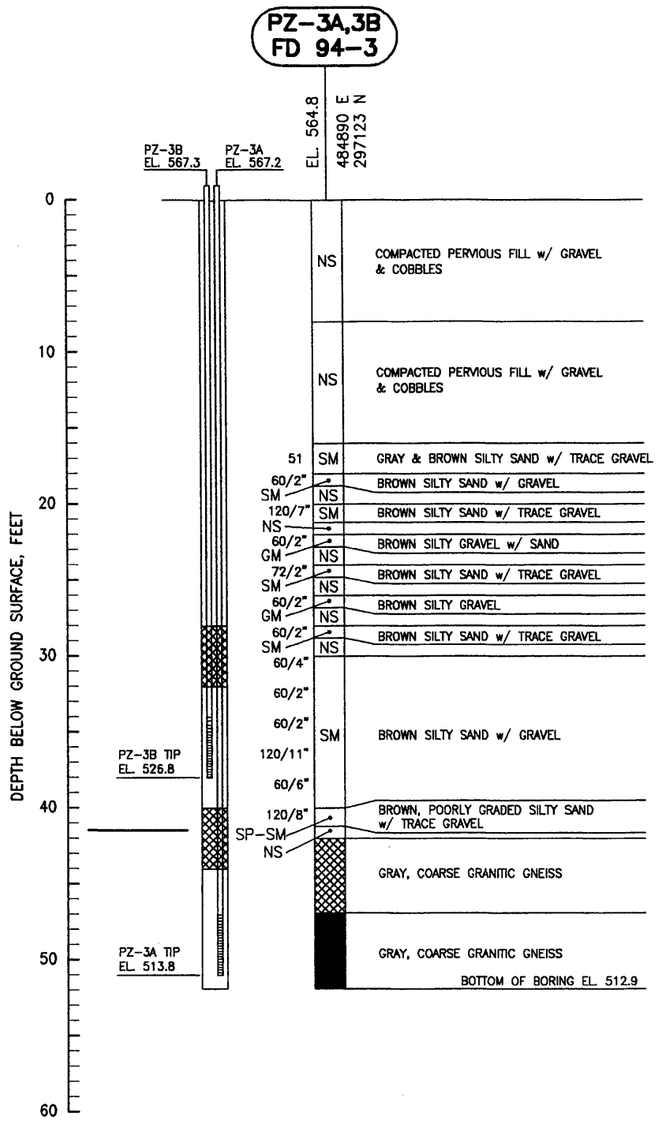
NOTES:

1. SEE PLATE 6 FOR BORING LOCATIONS.
2. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

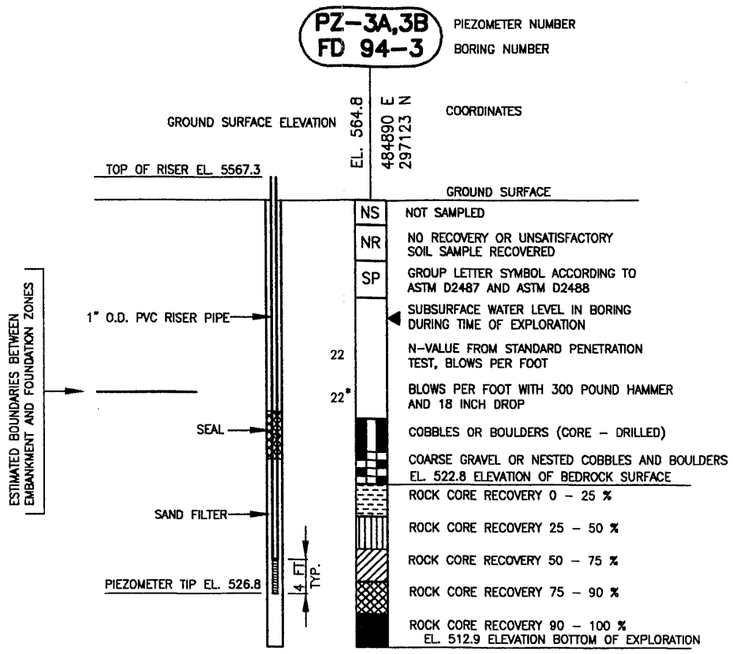


97494-04 10/28/97 DJM

U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	ENGINEERING LOGS FD94-2
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 8

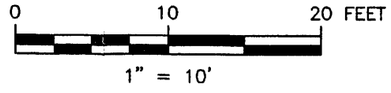


LEGEND FOR GRAPHIC LOG



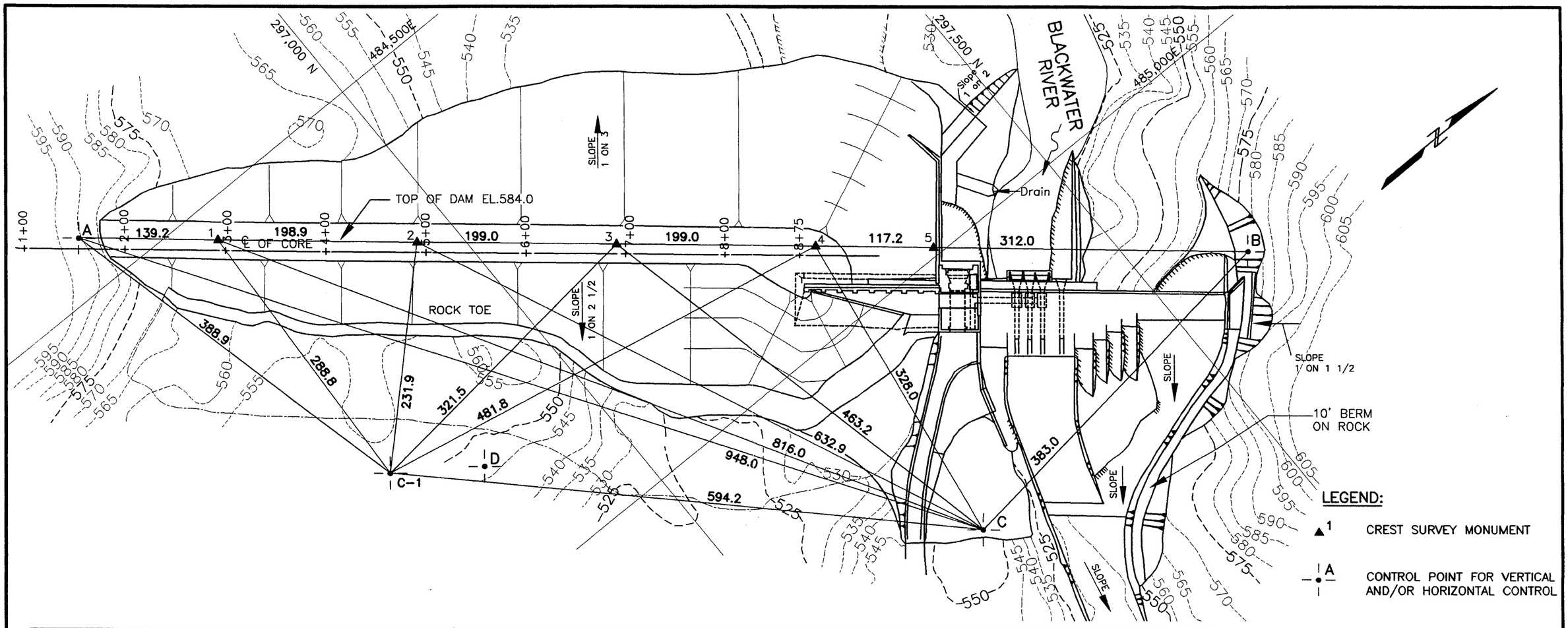
NOTES:

1. SEE PLATE 6 FOR BORING LOCATIONS.
2. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.



97494-04 10/28/97 DJM

U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	ENGINEERING LOGS FD94-3
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 9



LEGEND:

▲1 CREST SURVEY MONUMENT

A CONTROL POINT FOR VERTICAL AND/OR HORIZONTAL CONTROL

CREST MONUMENT COORDINATE DATA

	OCTOBER 1975			APRIL 1978			MARCH 1986			JUNE 1991			JUNE 1996		
MON.#	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	ELEVATION
1	N/R	N/R	585.107	296808.953	484535.164	585.108	296808.941	484535.228	585.115	296808.941	484535.228	585.110	296809.079	484535.307	585.091
2	N/R	N/R	585.291	296961.906	484662.561	585.294	296961.907	484662.657	585.296	296961.845	484662.615	585.279	296961.949	484662.611	585.282
3	N/R	N/R	585.251	297114.751	484789.786	585.335	297114.807	484789.903	585.304	297114.807	484789.903	585.262	297114.887	484789.922	585.264
4	N/R	N/R	585.035	297267.770	484917.140	585.033	297267.688	484917.270	585.030	297267.688	484917.270	585.013	297267.830	484917.279	585.000
5	N/R	N/R	556.790	N/R	N/R	556.759	N/R	N/R	556.788	N/R	N/R	556.80	N/R	N/R	556.731

CONTROL POINTS COORDINATE DATA

CONTROL POINT	NORTHING	EASTING	ELEVATION
A	296702.084	484446.188	592.65
B	297597.704	485191.807	580.87
C	297218.911	485241.480	N/R
C-1	296795.200	484823.819	N/R
D	296872.457	484878.170	N/R

NOTES:

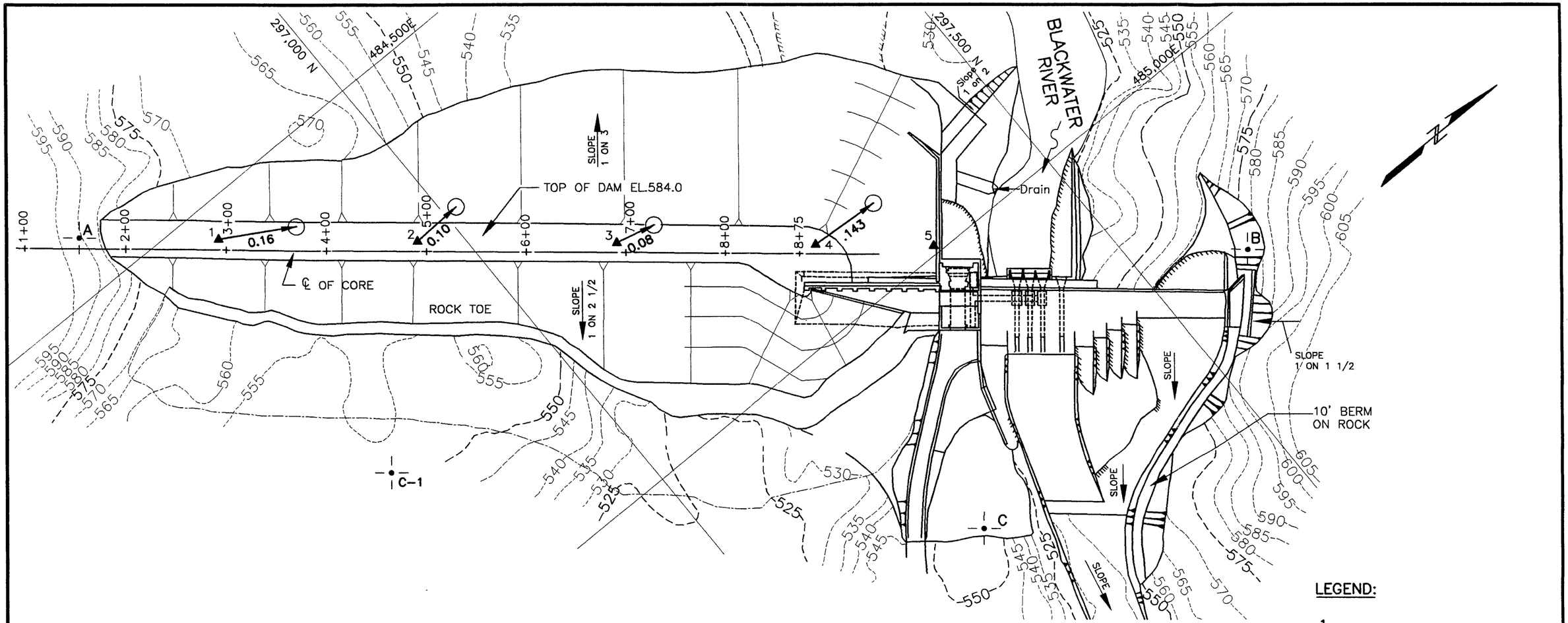
1. ALL ELEVATIONS SHOWN ON THIS SHEET ARE IN TERMS OF FEET NGVD.
2. BASE PLAN AND SURVEY DATA PROVIDED BY CORPS OF ENGINEERS.
3. MEASUREMENTS SHOWN (FEET) ARE FROM JUNE, 1996 SURVEY. REFER TO SURVEY BOOK F C 395 AND PLAN SUR-389 FOR DESCRIPTION AND LOCATION OF CONTROL POINTS. BOOK STORED IN NEDED DESIGN BRANCH, SURVEY UNIT. PLAN STORED IN NEDED DESIGN BRANCH, CIVIL LAYOUT SECTION.
4. N/R INDICATES INFORMATION NOT RECORDED.
5. WITH EDM SET ON CONTROL POINT "C-1" CREST MONUMENT 5 COULD NOT BE SIGHTED DUE TO ITS VERTICAL LOCATION APPROXIMATELY 29 FEET BELOW CREST OF EMBANKMENT.
6. CONTROL POINT C-1 ESTABLISHED AT THE 1991 SURVEY.

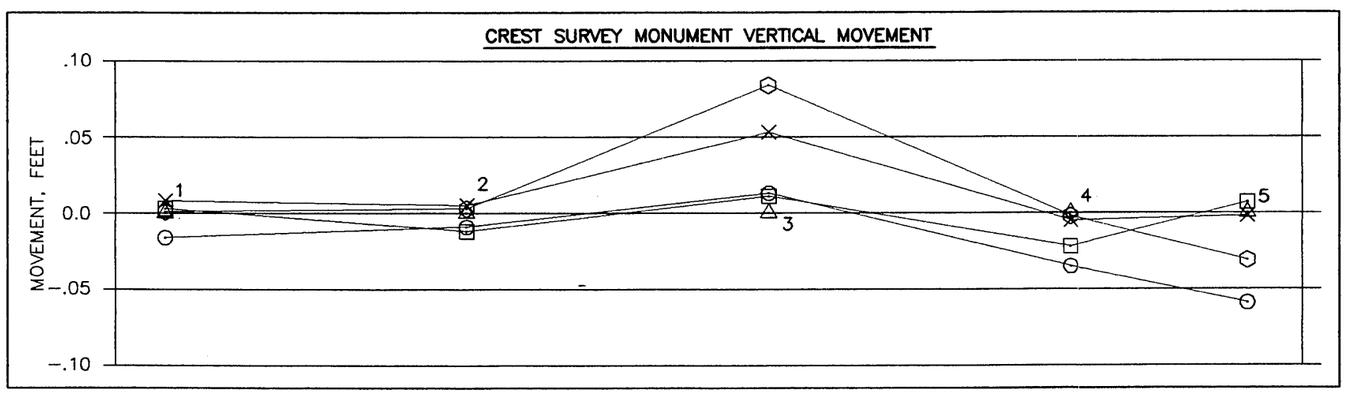
0 100 200

SCALE, FEET

U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	CREST SURVEY MONUMENTS: GENERAL LAYOUT, LOCATION & SURVEY DATA
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 10

97494-02 11/20/97 PWP/DJM





LEGEND FOR VERTICAL MOVEMENT	
SYMBOL	DESCRIPTION
△	CREST MONUMENT SURVEY INITIAL ELEVATION OCT. 1975
⊙	CREST MONUMENT SURVEY APRIL 1978
×	CREST MONUMENT SURVEY MARCH 1986
⊡	CREST MONUMENT SURVEY JUNE 1991
⊙	CREST MONUMENT SURVEY JUNE 1996

LEGEND:

▲1 CREST SURVEY MONUMENT

A CONTROL POINT FOR VERTICAL AND/OR HORIZONTAL CONTROL

.143 DIRECTION OF HORIZONTAL MOVEMENT BETWEEN 1991 AND 1996
SCALE: 1 INCH = 0.20 FEET

NOTES:

1. ALL ELEVATIONS SHOWN ON THIS SHEET ARE IN TERMS OF FEET NGVD.
2. PLAN DRAWING PROVIDED BY CORPS OF ENGINEERS.

0 0.20 0.40
HORIZONTAL MOVEMENT SCALE, FEET
1" = 0.20'

0 100 200
PLAN SCALE, FEET
1" = 100'

97494-03 9/25/97 PWP/DJM

U.S. Army Corps of Engineers
Waltham, Massachusetts

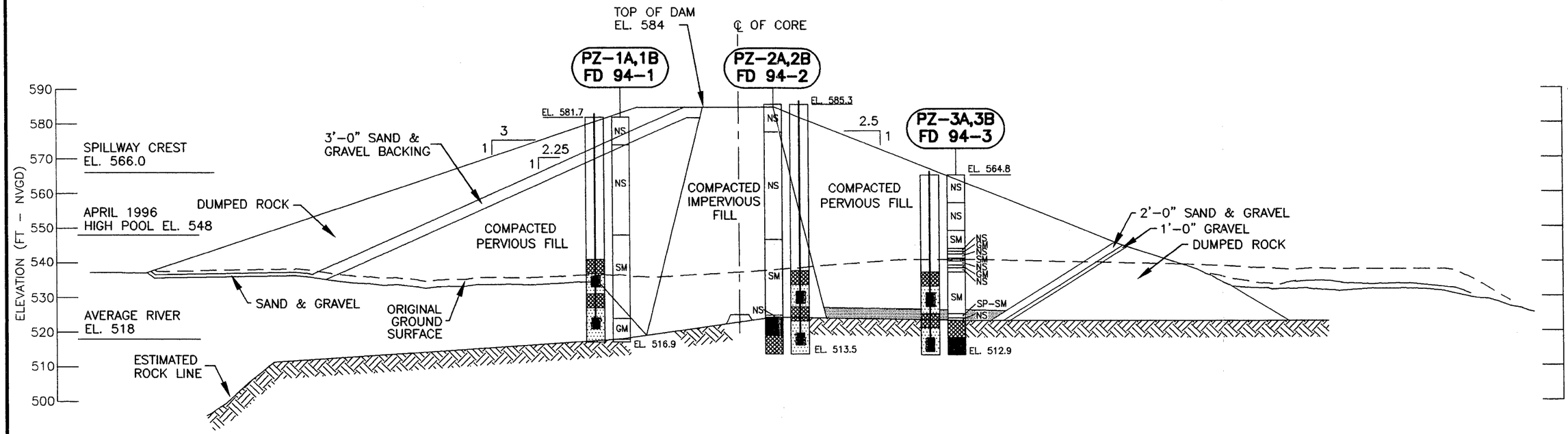
GEI Consultants, Inc.

Instrumentation Evaluation
Blackwater Dam
New Hampshire

Project 97494

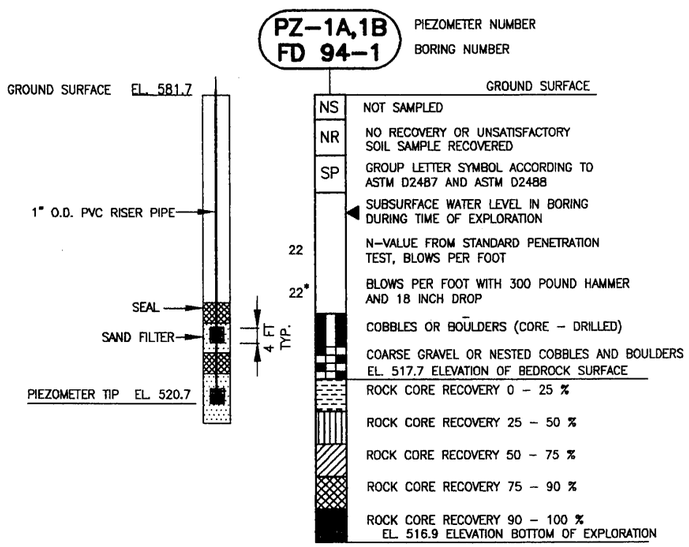
CREST SURVEY MONUMENTS: HORIZONTAL & VERTICAL MOVEMENTS

Nov. 1997 Plate 11



SECTION A–A – STATION 7+60

LEGEND FOR GRAPHIC LOG



NOTES:

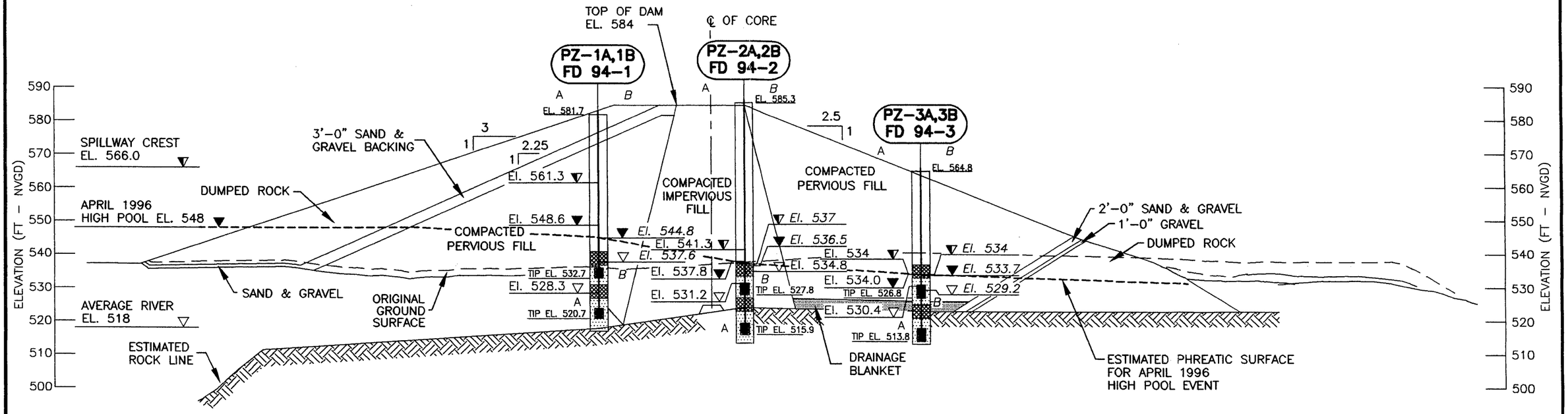
1. SEE PLATE 6 FOR BORING LOCATIONS.
2. SEE PLATES 7, 8, 9 FOR BORING LOGS.
3. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

0 30 60

SCALE, FEET

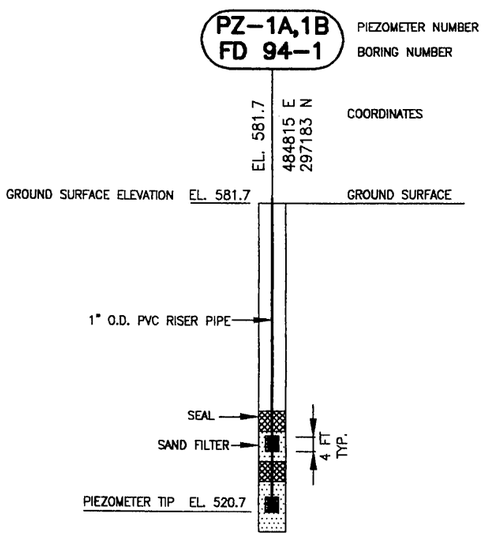
U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	STATION 7+60
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 12

97494-05 11/20/97 DJM



SECTION A–A – SECTION 7+60

LEGEND FOR GRAPHIC LOG



LEGEND:

- ▽ PROJECTED PIEZOMETER READINGS
- ▼ MAXIMUM RECORDED GROUND WATER ELEVATION DURING APRIL 1996 HIGH POOL EVENT
- ▽ AVERAGE NORMAL GROUND WATER ELEVATION (DATA FROM 1992–1997)
- ----- ESTIMATE PHREATIC SURFACE FOR APRIL 1996 HIGH POOL EVENT

NOTES:

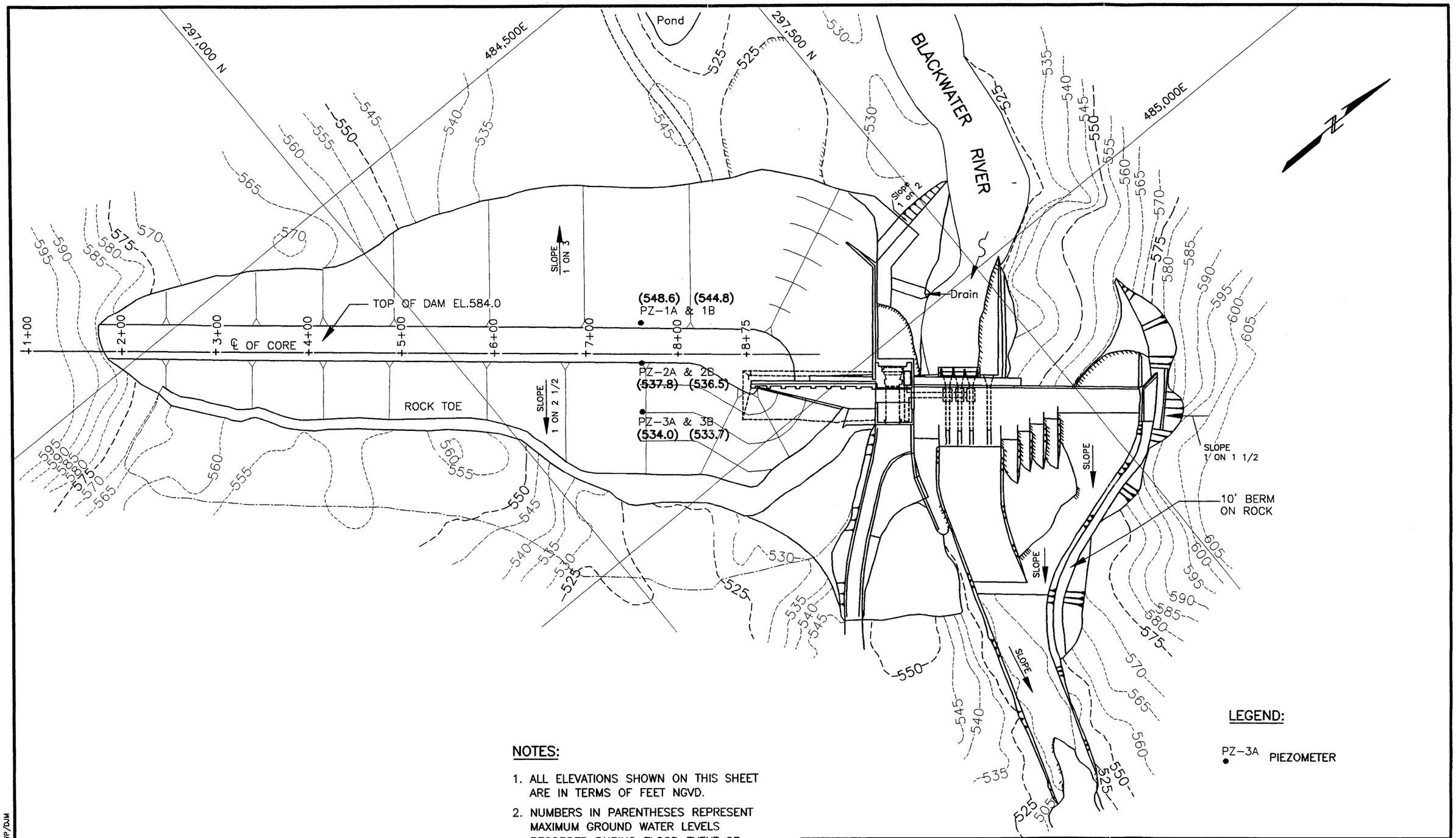
1. SEE PLATE 6 FOR BORING LOCATIONS.
2. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.
3. NO PROJECTION OF PIEZOMETRIC ELEVATION WAS MADE FOR PZ–1B DUE TO SCATTER OF DATA.

0 30 60

SCALE, FEET

U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	STATION 7+60 WITH PIEZOMETRIC PORE WATER ELEVATIONS
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 13

97494-06 11/20/97 DJM



NOTES:

1. ALL ELEVATIONS SHOWN ON THIS SHEET ARE IN TERMS OF FEET NGVD.
2. NUMBERS IN PARENTHESES REPRESENT MAXIMUM GROUND WATER LEVELS RECORDED DURING FLOOD EVENT OF APRIL 1996.
3. MAXIMUM POOL WAS EL. 550.0 WHICH OCCURRED ON APRIL 19, 1996.

0 100 200
SCALE, FEET

U.S. Army Corps of Engineers Waltham, Massachusetts	Instrumentation Evaluation Blackwater Dam New Hampshire	MAXIMUM GROUND WATER ELEVATION
GEI Consultants, Inc.	Project 97494	Nov. 1997 Plate 14

97494-07 9/25/97 PWP/DJH

CORPS OF ENGINEERS, U. S. ARMY
NEW ENGLAND DIVISION
FOUNDATION AND MATERIALS BRANCH

FIELD LOG OF TEST BORING

PROJECT NO. _____

Site BLACK RIVER DAM — Page 1 of 10 Pages

Hole No. FD-94-1 Diam. (Casing) 6" — Boring Started 7-16-94

Co-ordinates: N 297183 E 484815 — Boring Completed 7-18-94

Drilled by DAVID BOWDEN MOBILE DISTRICT — Report Submitted _____

Purpose of Exploration SET PZ-1 A & B

Elevation Top of Hole 581.7 N/A M.S.L. — Casing Left in Place 10' PROTECTIVE PIPE Feet

Total Overburden Drilled 64.4 Feet

Elevation Top of Rock N/A 517.3 M.S.L.

Elevation Bottom of Hole N/A 516.9 M.S.L.

Total Rock Drilled 0.4 (RB) Feet

Total Depth of Hole 64.8 Feet

Core Recovered N/A %

Core Recovered N/A Ft.: N/A Diam. ____ in.

Soil Samples 1 3/8 in. Diam. 16 No.

Soil Samples _____ in. Diam. ____ No. — Water Table Depth 52.9

Depth From	Depth To	Method of Drilling and Type of Bit Used
0	8'	6" CASING W/ DIA BIT TO CUT
		THRU LG BOULDER CLEAN OUT
		W/ 5 5/8 (RB) SET 12'6" 6" CASING
8.0	34.0	ADVANCE BORING W/ 5 5/8 (RB)
34.0	64.4	STD S/S W/ 1 3/8" ID SPLITSPOON &
		5 5/8 RB.
64.4	64.8	5 5/8 (RB)

INDEX

Prepared by Douglas Lowe
Field Data — Lab. Data

Submitted by _____

NED FORM DEC 63 121

REPLACES EDITION OF JUN 51 WHICH MAY BE USED UNTIL EXHAUSTED

PLATE A.1

U.S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

FIELD LOG OF TEST BORING

Site BLACKWATE DAM Page 2 of 10 Pages

Boring No. FD-94-1 Desig. 5 5/8 Diam. (Casing) 6"

Co-ordinates: N 297183 E 484815

Elevation Top of Boring 581.7 M.S.L.
Total Overburden Drilled 64.4 Feet
Elevation Top of Rock N/A 517.3 M.S.L.
Total Rock Drilled 0.4 (RB) Feet
Elevation Bottom of Boring N/A 516.9 M.S.L.
Total Depth of Boring 64.8 Feet
Core Recovered N/A % No. Boxes N/A
Core Recovered N/A Ft : N/A Diam. N/A In.
Soil Samples 3/8 In. Diam. 16 No.
Soil Samples ____ In. Diam. ____ No.

Hammer Wt. 140 lb Boring Started 7-16-94
Hammer Drop 18"
Casing Left N/A Boring Completed 7-18-94
Subsurface Water Data 52.9 Page ____
Obs. Well ____
Drilled By MOBILE (COE) DAVID BOWDEN
Mfg. Des. Drill FAILING 314
Inspected By: Douglas B. Jones
Classification By: Douglas B. Jones
Classification By: ____

DEPTH (In Ft.)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
0					REMOVE LARGE BOULDERS BY HAND TO GET 6" CASING STARTED. SET 5' 6" CASING.	NO SAMPLES
1					DRILLER USE 5 5/8 ROCK-BIT TO ADUANCE BORING THRU. RIP-RIP. & CONTD. W/ 6" CASING TO 10.7"	
2					CONTD. W/ 5 5/8 (RB) TO ADUANCE boring. MIX POLY-SAL @ 11.0	
3						
4						
5						

GENERAL REMARKS:

Site BLACKWATER DAM
BLACKWATER RIVER, N.H.

Boring No. FD-94-1

Page 3 of 10

DEPTH (ft)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
6						RIP-RAP W/ COMPACTED PERVIOUS SOILS
7						
8						
9						
10					5 5/8 ROCK BIT	
11						COMPACTED PERVIOUS SOILS W/ GRAVS. & TR COBBLES.
12						
13						d-13.0
13					CONTD ON PAGE 3	

Site BLACKWATER C \ BLACKWATER RIVER, NH.	Boring No. FD-94-1	Page 4 of 10

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
14					$5\frac{5}{8}$ ROCKBIT	COMPACTED PERVIOUS SOILS W/ GRAVS. & TR COBBLES
15						
16						
17						
18						
19						
20						
21						d-21.0
					CONTD on PAGE 4	

Site BLACKWATER DAM BLACKWATER RIVER, N.H.	Boring No. FD-94-1	Page 5 of 10

DEPTH	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
22						
23						
24					5⅝ ROCKBIT	COMPACTED PERVIOUS SOILS W/ GRAVS. & TR COBBLES.
25						
26						
27						
28						
29						d-29.0

CONTD ON PAGE 5

Site	Boring No.	Page
BLACKWATER DAM BLACKWATER RIVER N.H.	FD-94-1	6 of 10

DEPTH in Ft.	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
30						
31						
32						COMPACTED PERVIOUS SOILS W/ GRAVS. & TR COBBLES.
33						
34						d-34.0
34	1-1			58 60	SAMPLE W/ 1 3/8 ID SPLITSPOON USING 140lb. HAMMER, 18 in. DROP	Gray Silty (15-25) SAND w/ Tr. Gravel 1/4"-1" SM
35						
36						
36	2-1			49 60	SAMPLE W/ 1 3/8 ID SPLITSPOON USING 140 lb HAMMER, W/ 18" DROP	Gray Silty (17) SAND w/ Tr. Gravel 1/4" - 1/2" SM
37						
					CONT'D ON PAGE 6	

Site	Boring No.	Page
BLACKWATER DAM BLACKWATER RIVER N.H	FD-94-1	7 of 10

DEPTH (ft)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
38	M-7			42 60	SAMPLE W/ 1 3/8 ID SPLITSPOON USING 140 lb HAMMER W/ 18" DROP	Gray Silty (15-25) SAND W/ Tr Gravel 1/4" - 1/2" SM
39						
40	M-8			45 60	SAMPLE W/ 1 3/8 ID SPLITSPOON USING 140 lb HAMMER W/ 18" DROP	
41						
42	M-9			59 60	SAMPLE W/ 1 3/8 ID SPLITSPOON USING 140 lb HAMMER W/ 18" DROP	
43						
44	M-10			60	SAMPLE W/ 1 3/8" ID SPLITSPOON USING 140 lb HAMMER W/ 18" DROP	
45					CONTD ON PAGE 7	

Site BLACKWATER DAM	Boring No. FD-94-1	Page 8 of 10

DEPTH (ft)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
46						
	J-7			46 / 60	SAMPLE W/ 1 3/8" ID SPLITSPOON USING 140lb HAMMER W/ 18" DROP	Gray Silty (18) SAND w/ Tr. Gravel 1/4" - 3/4" SM
47						
48	J-8			37 / 60	SAMPLE W/ 1 3/8" ID SPLITSPOON USING 140lb HAMMER W/ 18" DROP	Gray Silty (15-25) SAND w/ Tr. Gravel 1/4" - 1/2" SM
49						
50	J-9			58 / 60	SAMPLE W/ 1 3/8" ID SPLITSPOON USING 140lb HAMMER W/ 18" DROP	
51						
52	J-10			58 / 60	SAMPLE W/ 1 3/8" ID SPLITSPOON USING 140lb HAMMER W/ 18" DROP	
53					CONTD ON PAGE 8	

Site	Boring No.	Page
BLACKWATER DAM	FD-94-1	9 of 10

DEPTH	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
54						
				16	SAMPLE w/ 1 3/8" ID SPLITSPOON USING 140 lb HAMMER w/ 18" DROP	Gray Silty (23) SAND w/ Tr. Gravel 1/4" - 1/2" SM
55	J-11			28		
				34		
				60		
56				10		Gray Silty (20-30) SAND w/ Tr Gravel 1/4" - 1/2" SM
	J-12			12		
57				22	See Above	
				26		
58				22		Greenish Silty (10-20) GRAVEL GM
	J-13			35		
59				45		
				55		
60				60		Greenish Silty (14) GRAVEL GM
	J-14			66		
61					CONTD ON PAGE 9	

Site	Boring No.	Page / of
BLACKWATER DAM	FD-94-1	Page 10 of 10

DEPTH	CORE/SAMPLE			BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
	NQ	SIZE	DEPTH RUNS			
62	J-14			60 / 60	SAMPLE W/ 1 3/8" ID SPLITSPOON USING 140 lb HAMMER W/ 18" DROP	Greenish Silty (10-20) GRAVEL GM
63	J-15			18 / 25 / 23 / 25		
64	J-16			60		
					DRILLER USED 5 5/8 ER TO PENT. RK.	d-64.8 BOH

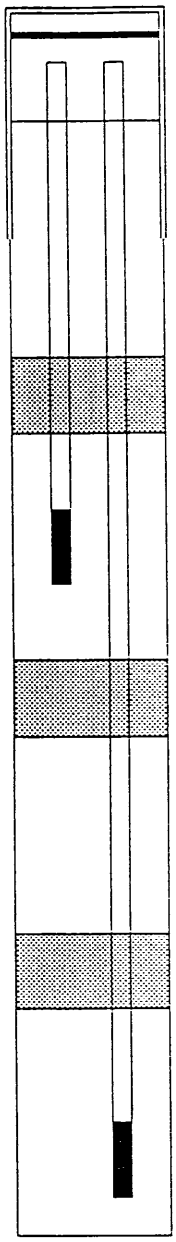
PIEZOMETER INSTALLATION LOG

PAGE of

Project	BLACKWATER DAM	Date	7-21-94
Northing		PZ Number	PZ-1 A & B
Easting		Hole Number	FD-94-1
Start	7-14-94	Inspector	Jones D
Complete	7-16-94	Pre-Install Pz Length	
Sounding	1A-61.0 1B-49.0	Riser Cut-off	

Piezometer "A" stick-up is always longer than piezometer "B".

All Depths are taken from the ground surface.



	PZ-A	PZ-B
Piezometer Stick-Up	1.9	2.0 NA
Ground Surface	0	
Type of Fill Material	RANDOM FILL	NA
Depth Bottom of Casing	D-8.0	NA
Dia. PVC Pipe /Schedule	3/4"	3/4
Depth Top of Plug	D-41.0	NA
Depth Bottom of Plug	D-45.0	NA
Type of Fill Material	PLAY-SAND	NA
Depth Piezometer Tip	NA	49.0
Depth Top of Plug	N/A	NA
Depth Bottom of Plug	N/A	NA
Type of Fill Material	PLAY SAND	NA
Depth Top of Plug	D-51.0	NA
Depth Bottom of Plug	D-55.0	NA
Type of Fill Material	PLAY-SAND	NA
Depth Piezometer Tip	D-61.0	NA

Notes:

PLATE A.11

Site: BLACKWATER DAM
Boring No: ED 94-1

SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-19				52.9		PZ-1A
				43.8		PZ-1B
7-20				54.9		PZ-1A
				44.2		PZ-1B
7-21				55.3		PZ-1A
				43.9		PZ-1B

Note: Depths are in feet below original ground

BORING LOCATION SKETCH

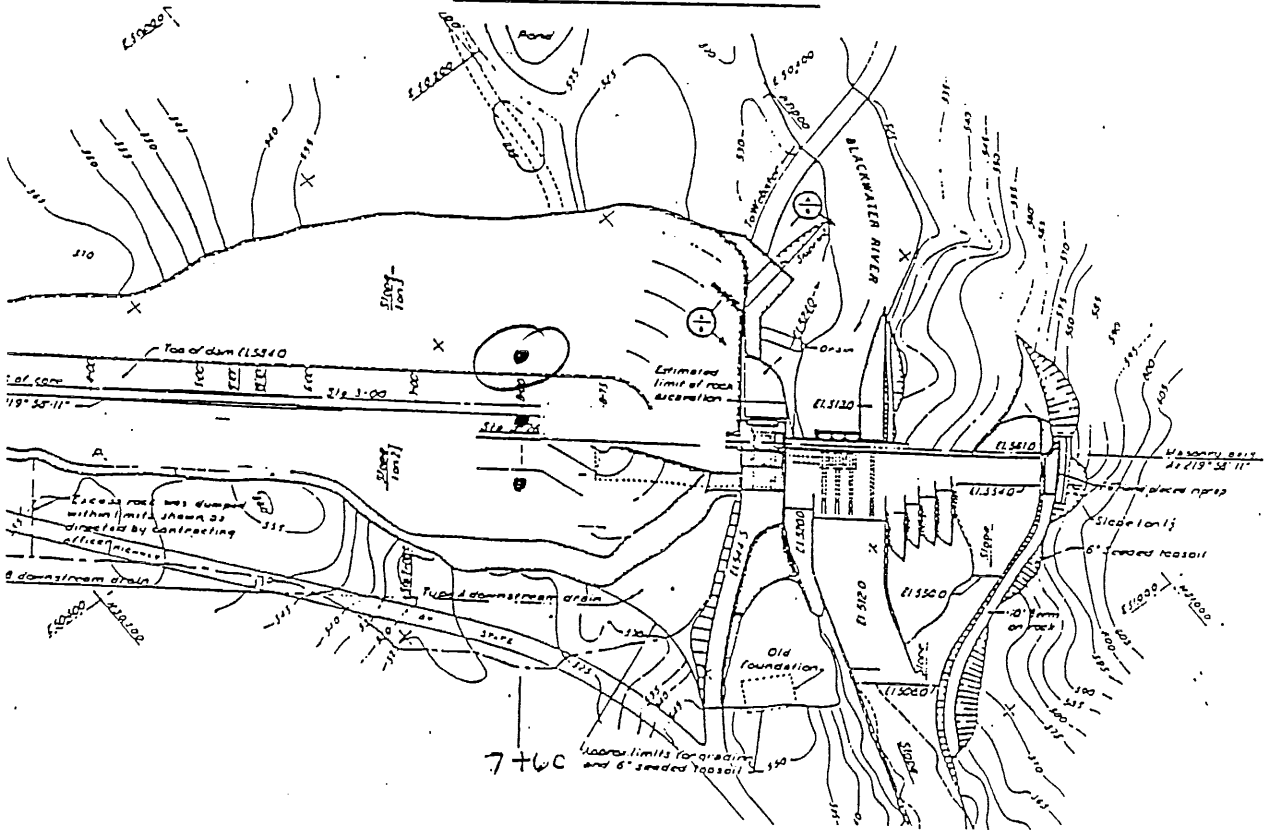


PLATE A.12

NED FORM 59 (Test)

FIELD LOG OF TEST BORING IN ROCK

SITE _____ HOLE NO. _____ PAGE _____

DATE	DEPTH PT. FROM	DEPTH PT. TO	RUN PT.	RUN REC'V'Y PT.	REC'V'Y %	DRILLING BEHAVIOR: FEED	DRILLING BEHAVIOR: WATER	DRILLING BEHAVIOR: REASON FOR POLL	ACTUAL DRILLING TIME	BIT NO. SIZE AND TYPE	ADDITIONAL REMARKS

NO ROCK CORED

TOTAL BED ROCK DRILLED _____ FEET

TOTAL BED ROCK RECOVERED _____ FEET

BED ROCK RECOVERY _____ PERCENT

DRILLER _____

INSPECTOR _____

NED FORM DEC 63 130

REPLACES EDITION OF APR 63 WHICH MAY BE USED UNTIL EXHAUSTED

PLATE A.13

PLATE A.14

09/02/94

SITE: Blackwater Dam BORING NUMBER: FD94-01

DATE: 07/21/94 PIEZOMETER NUMBER PZ-1A

START TIME: 08:17:00 DATUM ELEVATION: 583.68

POOL ELE.: 516.10 INTIAL WATER DEPTH FROM TOP OF RISER 52.90

LAPSE TIME	CLOCK TIME	DEPTH	ELEVATION
00:00:00	08:17:00 AM	0.00	583.7
00:00:15	08:17:15 AM	1.50	582.2
00:00:30	08:17:30 AM	1.90	581.8
00:01:00	08:18:00 AM	2.30	581.4
00:02:00	08:19:00 AM	3.80	579.9
00:04:00	08:21:00 AM	8.10	575.6
00:08:00	08:25:00 AM	11.80	571.9
00:15:00	08:32:00 AM	19.00	564.7
00:30:00	08:47:00 AM	26.80	556.9
01:00:00	09:17:00 AM	32.40	551.3
02:00:00	10:17:00 AM	36.20	547.5

DATE REVISED: 09/02/94

INSPECTOR: Doug Jones

REMARKS:

BWPZ01AF.WK4

09/02/94

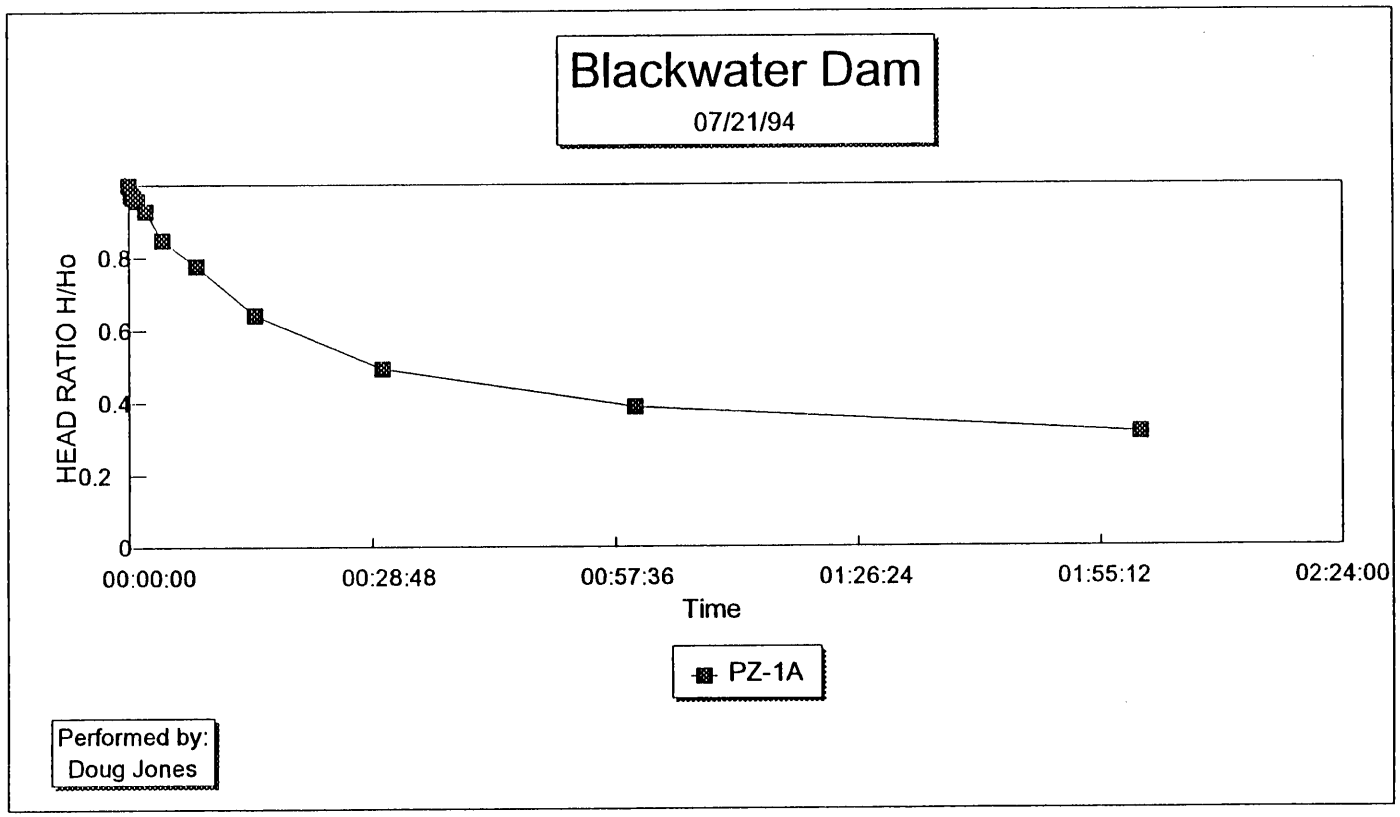


PLATE A.15

BWPZ01AF.WK4

PLATE A.16

09/02/94

SITE: Blackwater Dam BORING NUMBER: FD94-01

DATE: 07/21/94 PIEZOMETER NUMBER PZ-1B

START TIME: 08:10:00 DATUM ELEVATION: 583.75

POOL ELE.: 516.10 INTIAL WATER DEPTH FROM TOP OF RISER 43.80

LAPSE TIME	CLOCK TIME	DEPTH	ELEVATION
00:00:00	08:10:00 AM	0.00	583.8
00:00:15	08:10:15 AM	0.50	583.3
00:00:30	08:10:30 AM	0.80	583.0
00:01:00	08:11:00 AM	1.00	582.8
00:02:00	08:12:00 AM	1.20	582.6
00:04:00	08:14:00 AM	2.40	581.4
00:08:00	08:18:00 AM	4.40	579.4
00:15:00	08:25:00 AM	9.60	574.2
00:30:00	08:40:00 AM	19.30	564.5
01:00:00	09:10:00 AM	25.30	558.5
02:00:00	10:10:00 AM	31.50	552.3

DATE REVISED: 09/02/94

INSPECTOR: Doug Jones

REMARKS:

BWPZ01BF.WK4

09/02/94

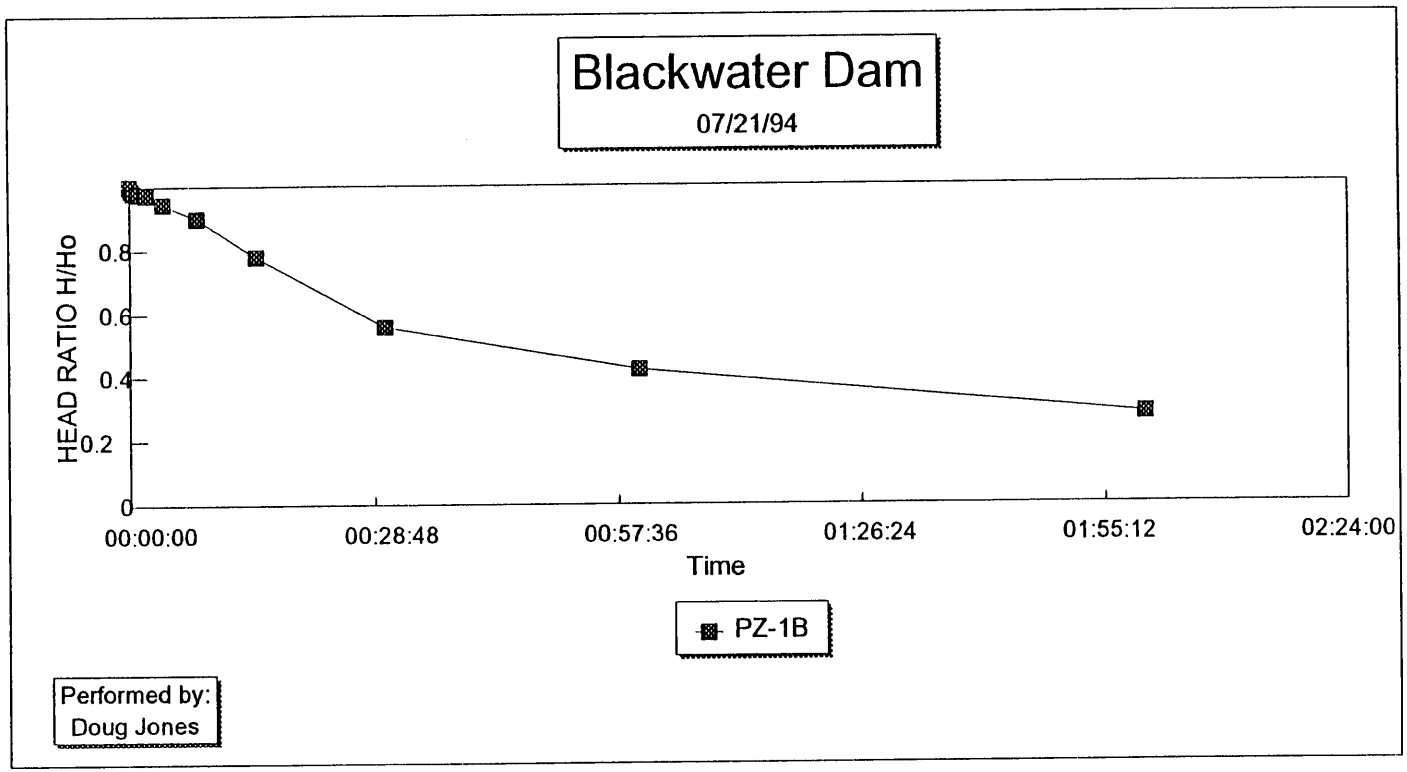


PLATE A.17

BWPZ01BF.WK4

CORPS OF ENGINEERS, U. S. ARMY
NEW ENGLAND DIVISION
FOUNDATION AND MATERIALS BRANCH

FIELD LOG OF TEST BORING

Site BLACKWATER DAM PROJECT NO. _____

Page 1 of 10 Pages

Hole No. FD-94-2 Diam. (Casing) 6"

Boring Started 7-16-94

Co-ordinates: N 297156 E 484849

Boring Completed 7-18-94

Drilled by DAVID BOWDEN MOBILE DISTRICT

Report Submitted _____

Purpose of Exploration SET PZ-2 A & B

Elevation Top of Hole N/A 585.3 M.S.L.

Total Overburden Drilled 61.4 Feet

Elevation Top of Rock N/A 523.9 M.S.L.

Elevation Bottom of Hole N/A 513.5 M.S.L.

Total Rock Drilled 10.4 Feet

Total Depth of Hole 71.8 Feet

Core Recovered _____ %

Core Recovered 8.9 Ft.: ____ Diam. ____ In.

Soil Samples 1 3/8 ID In. Diam. 11 No.

Soil Samples N/A In. Diam. ____ No.

Casing Left in Place 10' PROTECTIVE PIPE Feet

Water Table Depth 55.7

Depth From	Depth To	Method of Drilling and Type of Bit Used
0.0	8.0	DRILL AUG DORING TO 8' W/
		8" AUG SET 7'6" 6" CASING
		MIX 'POLY-SAL @ 8.0
8.0	39.0	ADVANCE DORING W/ 5 5/8 RB
39.0	61.4	STD S/S W/ 1 3/8" ID SPLITSPOON
61.4	71.8	HQ W.L. 2 3/4 X 3 7/8

INDEX

Prepared by Douglas B. Jones
Field Data

Submitted by _____

Lab. Data

NED FORM DEC 63 121

REPLACES EDITION OF JUN 51 WHICH MAY BE USED UNTIL EXHAUSTED

PLATE A.18

U.S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

FIELD LOG OF TEST BORING

Site BLACKWATER DAM Page 2 of 10 Pages

Boring No. FD-94-2 Desig. 598 Diam. (Casing) 6"

Co-ordinates: N 297156 E 484849

Elevation Top of Boring 585.3 N/A M.S.L.
Total Overburden Drilled 61.4 Feet
Elevation Top of Rock N/A 523.9 M.S.L.
Total Rock Drilled 10.4 Feet
Elevation Bottom of Boring N/A M.S.L.
Total Depth of Boring 71.8 Feet
Core Recovered ____ % No. Boxes 1
Core Recovered 8.9 Ft: ____ Diam. ____ in.
Soil Samples 1 3/8" ID in. Diam. II No.
Soil Samples N/A in. Diam. ____ No.

Hammer Wt. 140lb Boring Started 7-16-91
Hammer Drop 18"
Casing Left N/A Boring Completed 7-18-91
Subsurface Water Data 55.7 Page ____
Obs. Well ____
Drilled By MOBILE DISTRICT DAVID BOWDEN
Mfg. Des. Drill FAILING 314
Inspected By: Douglas B. Jones
Classification By: ____
Classification By: ____

DEPTH 1"=1'	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
1					DRILLER USE 8" AUG TO ADVANCE BORING TO 8'. SET 7'6" 6" CASING MIX POLY-SAL. USE 5 5/8 RB TO ADVANCE BORING	COMPACTED IMPERVIOUS FILL W/ GRAV & COBBLES
2						
3						
4						
5						

GENERAL REMARKS:

Site	Boring No.	Page 3 of 10
BLACKWATER JAM	FD-94-2	

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
6					CONTD W/ 5⅝ RB TO ADVANCE BORING	COMPACTED IMPERVIOUS FILL W/ GRAV. & COBBLES
8						COMPACTED IMPERVIOUS FILL W/ GRAVS & RK FRAGS

Site	Boring No.	Page
BLACKWATER DAM	FD-94-2	4 of 10

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. CORE REC'VT	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
14						COMPACTED IMPERVIOUS FILL W/ GRAV & RK FRAGS
15						
16						
17						
18					CONTD W/ 5⅝ RB	
19						
20						
21						
22						

Site	Boring No.	Page 5 of 10
BLACKWATER DAM	FD-94-2	

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
23						COMPACTED IMPERVIOUS FILL W/ GRAV. & RK FRAGS.
24						
25						
26					CONTD W/ 5 5/8 RB	
27						
28						
29						
30						

Site	Boring No.	Page / of
BLACKWATER DAM	FD-94-2	Page 6 of 10

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
31						COMPACTED IMPERVIOUS FILL W/ GRAV & RK FRAGS
32						
33						
34						
35					CONTD W/ 5 5/8 RB	
36						
37						
38						
39						

Site	Boring No.	Page 7 of 10
BLACKWATER DAM	FD-94-2	

DEPTH	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
40	J-1			8	Sample w/ 1 3/8" ID SPLITSPOON, 140 lb HAMMER w/ 18" drop	Gray Silty (23) SAND w/ Tr. Gravel 1/4" - 1/2" SM
				16		
				23		
41				34		
	J-2			18		Gray Silty (20-30) SAND w/ Tr. Gravel 1/4" - 3/4" SM
42				29		
				52		
43				33		
	J-3			11		
44				26		
				29		
45				46		
	J-4			13		
46				19		
				24		
47				60		
	J-5			18		

CONTD ON NEXT PAGE

Site	Boring No.	Page 8 of 10
BLACKWATER Dam	FD-94-2	

DEPTH (ft)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
48				25	SAMPLE w/ 1 3/8" ID SPLITSPOON, 140 lb Hammer w/ 18" drop	Gray Silty (20-30) SAND w/ Tr. Gravel 1/4" - 3/4" SM
	J-5			20		
49				35		
				14		
50	J-6			31		
				31		
51				40		
				24		
52	J-7			31		
				45		
53				31		
				11		
54	J-8			21		
				27		
55				60		
	J-9			23		Gray Silty (24) SAND w/ Tr. Gravel 1/4" - 3/4" SM
56				37		

Site	Boring No.	Page 9 of 18
BLACKWATER DAM	FD-94-2	

DEPTH (ft)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
57	J-9			32 40	SAMPLE W/ 1 3/8" ID SPLITSPOON, 140 lb Hammer W/ 18" drop	Gray Silty (20-30) SAND w/ Tr. Gravel 1/4" - 3/4" SM
58	J-10			20 35 35 38		
59	J-11			11 19 21 60		
61				60		NO SAMPLE TPRK 614
61.4						
62				B X		P-1 RAN - 5.2 REC - 4.9 L - 0.3
63				1 0F 1		Drill Time - 1 hr 49 mins " Action - Rough Hyd Pressure - 150-200 Water return - 100%
64						

Site	Boring No.	Page / of
BLACKWATER DAM	FD-94-2	Page 10 of 10

DEPTH (ft)	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
66				B		
				A		
67						P-2 RAN- 5.2 REC- 4.0 L- 1.2 DRILL TIME - 1Hr 32mins N ACTION - ROUGH Hyd press - 150-200 WATER return - 100%
68						
				1		
69						
				0 F		Grey Coarse Granitic Gneiss
70						
				1		
71						
71.8						d-71.8 BOH

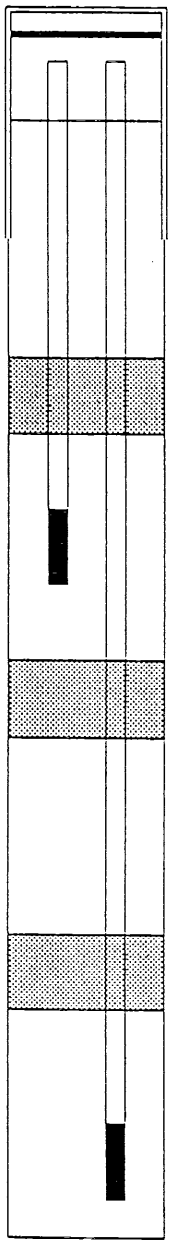
PIEZOMETER INSTALLATION LOG

PAGE of

Project	BLACKW ER DAM	Date	7-22-94
Northing		PZ Number	PZ-2A&B
Easting		Hole Number	FD-94-2
Start	7-16-94	Inspector	Jones D
Complete	7-18-94	Pre-Install Pz Length	
Sounding	PZ-2A 69.4 PZ-2B- 57.5	Riser Cut-off	

Piezometer "A" stick-up is always longer than piezometer "B".

All Depths are taken from the ground surface.



	PZ-A	PZ-B
Piezometer Stick-Up	1.9	2.0 NA
Ground Surface	0	
Type of Fill Material	RANDOM FILL	NA
Depth Bottom of Casing	8.0	NA
Dia. PVC Pipe /Schedule	3/4"	3/4"
Depth Top of Plug	48.0	NA
Depth Bottom of Plug	52.0	NA
Type of Fill Material	CLAY-SAND	NA
Depth Piezometer Tip	NA	57.5
Depth Top of Plug	N/A	NA
Depth Bottom of Plug	N/A	NA
Type of Fill Material	CLAY-SAND	NA
Depth Top of Plug	59.5	NA
Depth Bottom of Plug	63.5	NA
Type of Fill Material	CLAY-SAND	NA
Depth Piezometer Tip	69.4	NA

Notes:

PLATE A.28

PZINSTAL.WK4

Site: BLACKWATER DAM
Boring No: FD-94-2

SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-20				55.7		PZ-2A
				46.5		2B
7-21				56.3		PZ-2A
				48.4		2B

Note: Depths are in feet below original ground

BORING LOCATION SKETCH

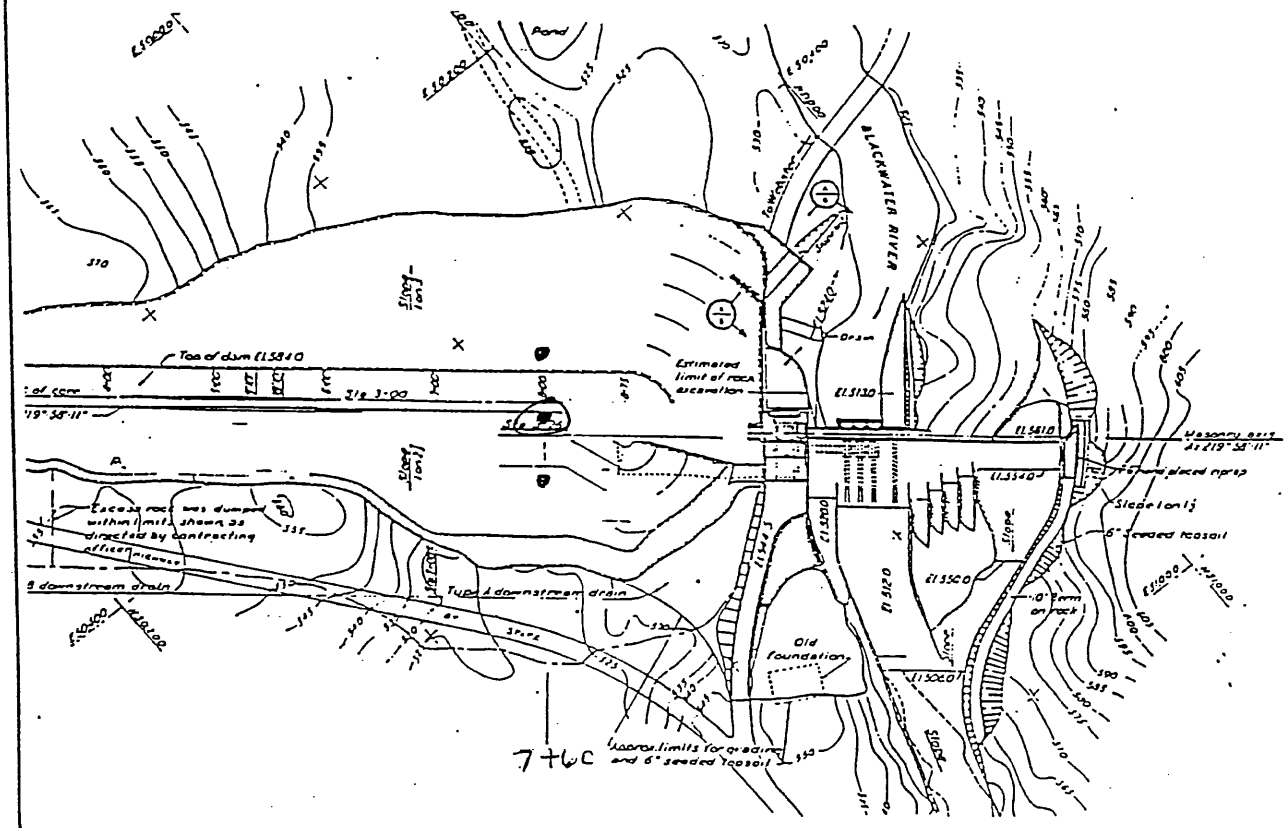


PLATE A.30

FIELD LOG OF TEST BORING IN ROCK

SITE BLACKWATER DAM ROLE NO. FD-94-2 PAGE

DATE	DEPTH PT. FROM	DEPTH PT. TO	RUN PT.	RUN REC'V'Y PT.	REC'V'Y %	DRILLING BEHAVIOR: FEED	DRILLING BEHAVIOR: WATER	DRILLING BEHAVIOR: REASON FOR PULL	ACTUAL DRILLING TIME	BIT NO. SIZE AND TYPE	ADDITIONAL REMARKS
7-18	61.4	66.6	5.2	4.9			100%	STOP Cutting	1 hr 49 mins	HQ	
	66.6	71.8	5.2	4.0			—		1 hr 32 mins	HQ	

TOTAL BED ROCK DRILLED 10.4 FEET

TOTAL BED ROCK RECOVERED 9.9 FEET

BED ROCK RECOVERY _____ PERCENT

DRILLER DAVID BOWDEN

INSPECTOR DOUG JONES

NED FORM DEC 63 130

REPLACES EDITION OF APR 63 WHICH MAY BE USED UNTIL EXHAUSTED

09/02/94

SITE: Blackwater Dam

BORING NUMBER: FD94-02

DATE: 07/21/94

PIEZOMETER NUMBER PZ-2A

START TIME: 09:43:00

DATUM ELEVATION: 587.27

POOL ELE.: 516.10

INTIAL WATER DEPTH FROM TOP OF RISER 55.70

LAPSE TIME	CLOCK TIME	DEPTH	ELEVATION
00:00:00	09:43:00 AM	0.00	587.3
00:00:15	09:43:15 AM	NA	NA
00:00:30	09:43:30 AM	NA	NA
00:01:00	09:44:00 AM	38.20	549.1
00:02:00	09:45:00 AM	50.60	536.7
00:04:00	09:47:00 AM	54.30	533.0
00:08:00	09:51:00 AM	56.90	530.4
00:15:00	09:58:00 AM	57.50	529.8
00:30:00	10:13:00 AM	57.70	529.6
01:00:00	10:43:00 AM	57.70	529.6
02:00:00	11:43:00 AM	57.70	529.6

DATE REVISED: 09/02/94

INSPECTOR: Doug Jones

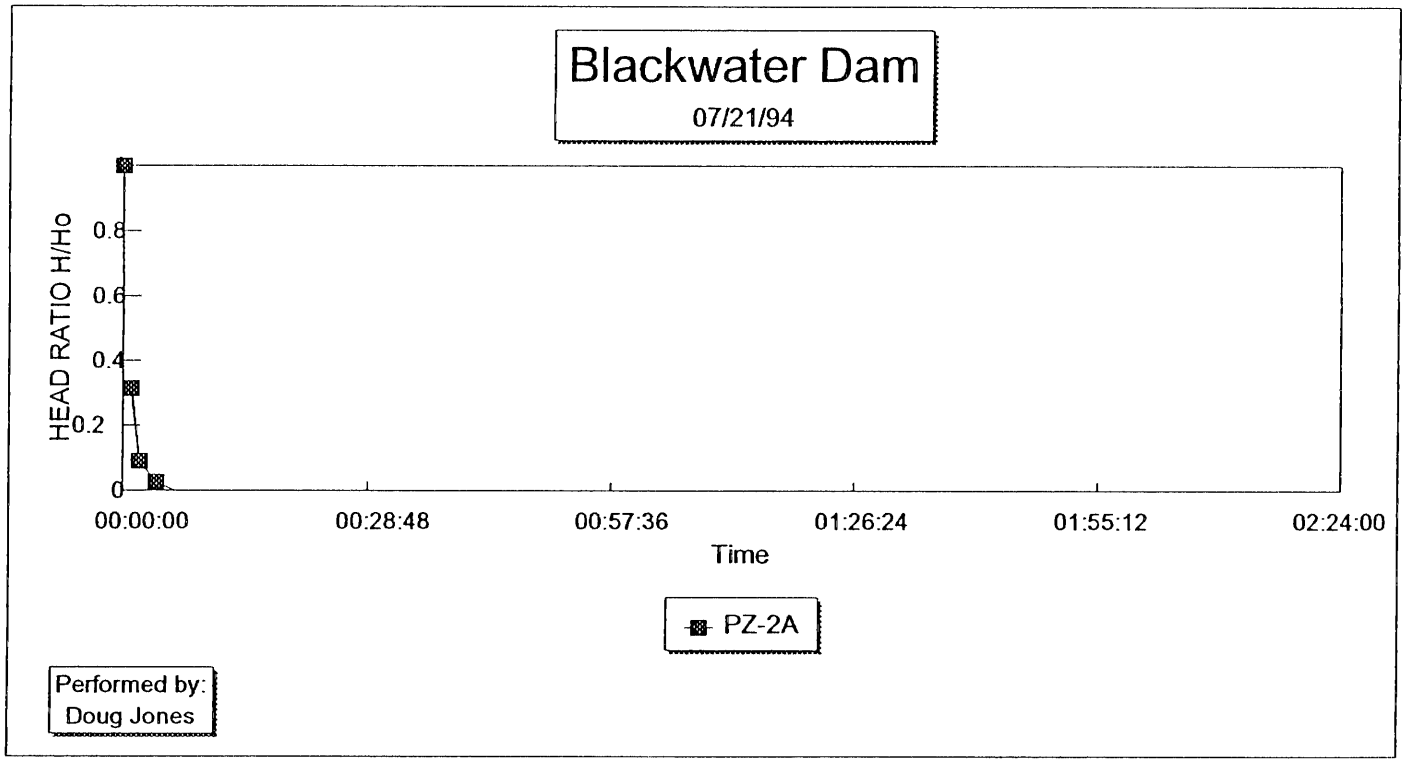
REMARKS:

PLATE A.31

BWPZ02AF.WK4

PLATE A.32

09/02/94



BWPZ02AF.WK4

09/02/94

SITE: Blackwater Dam

BORING NUMBER: FD94-02

DATE: 07/21/94

PIEZOMETER NUMBER PZ-2B

START TIME: 09:30:00

DATUM ELEVATION: 587.34

POOL ELE.: 516.10

INTIAL WATER DEPTH FROM TOP OF RISER 46.50

LAPSE TIME	CLOCK TIME	DEPTH	ELEVATION
00:00:00	09:30:00 AM	0.00	587.3
00:00:15	09:30:15 AM	0.30	587.0
00:00:30	09:30:30 AM	0.40	586.9
00:01:00	09:31:00 AM	0.60	586.7
00:02:00	09:32:00 AM	1.10	586.2
00:04:00	09:34:00 AM	1.50	585.8
00:08:00	09:38:00 AM	2.60	584.7
00:15:00	09:45:00 AM	4.40	582.9
00:30:00	10:00:00 AM	10.00	577.3
01:00:00	10:30:00 AM	14.20	573.1
02:00:00	11:30:00 AM	20.40	566.9

DATE REVISED: 09/02/94

INSPECTOR: Doug Jones

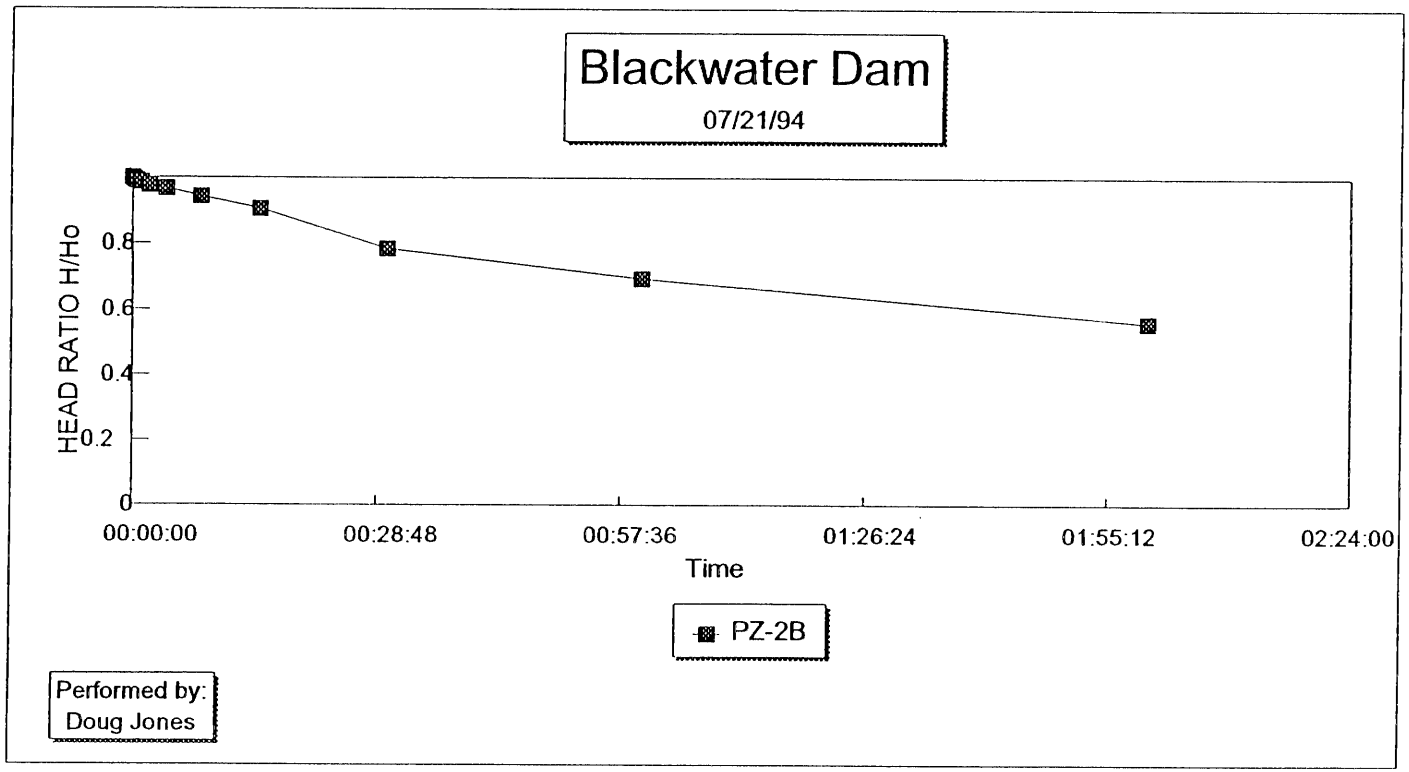
REMARKS:

PLATE A.33

BWPZ02BF.WK4

PLATE A.34

09/02/94



BWPZ02BF.WK4

CORPS OF ENGINEERS, U. S. ARMY
NEW ENGLAND DIVISION
FOUNDATION AND MATERIALS BRANCH

FIELD LOG OF TEST BORING

PROJECT NO. _____

Site BLACKWATER DAM — Page 1 of 8 Pages

Hole No. FD-94-3 Diam. (Casing) 6" — Boring Started 7-19-94

Co-ordinates: N 297123 E 1184890 — Boring Completed 7-21-94

Drilled by DAVID BOWDEN MOBILE DISTRICT — Report Submitted _____

Purpose of Exploration SET PZ-3 A & B

Elevation Top of Hole 564.8 N/A M.S.L. — Casing Left in Place 10' PROTECTIVE PIPE Feet

Total Overburden Drilled 42.0 Feet

Elevation Top of Rock N/A 522.8 M.S.L.

Elevation Bottom of Hole N/A 521.9 M.S.L.

Total Rock Drilled 9.9 Feet

Total Depth of Hole 51.9 Feet

Core Recovered _____ %

Core Recovered 9.2 Ft.: _____ Diam. _____ in.

Soil Samples 13/8 in. Diam. 13 No.

Soil Samples _____ in. Diam. _____ No. — Water Table Depth 55.7

Depth From	Depth To	Method of Drilling and Type of Bit Used
0.0	8.0	DRILLER AUG BORING TO 8'
		W 8" AUG. SET 7'6" 8"
		CASING MX POLY-SAL @
		8.0
8.0	16.0	ADVANCE BORING W/ 5-5/8 EB
16.0	42.0	STDS/S W/ 1 3/8" ID SPLITSPOON
42.0	51.9	HQ 2.34 X 3 7/8

INDEX

Ground Water _____ Back of Page _____

Boring Location Sketch _____ Back of Page _____

Overburden Record _____ Page _____

Rock Drilling _____ Page _____

_____ Page _____

_____ Page _____

_____ Page _____

Prepared by Douglas B. Lowe
Field Data — Lab. Data

Submitted by _____

NED FORM DEC 63 121

REPLACES EDITION OF JUN 51 WHICH MAY BE USED UNTIL EXHAUSTED

PLATE A.35

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

FIELD LOG OF TEST BORING

Site BLACKWATER DAM Page 2 of 8 Pages

Boring No. FD-943 Desig. 55/8 Diam. (Casing) 6"

Co-ordinates: N 297123 E 484890

Elevation Top of Boring N/A 564.8 M.S.L.
Total Overburden Drilled 42.0 Feet
Elevation Top of Rock N/A 522.8 M.S.L.
Total Rock Drilled 9.9 Feet
Elevation Bottom of Boring N.A 512.9 M.S.L.
Total Depth of Boring 51.9 Feet
Core Recovered ____ % No. Boxes 1
Core Recovered 9.2 Ft : ____ Diam. ____ In.
Soil Samples 13/8 ID In. Diam. 13 No.
Soil Samples ____ In. Diam. ____ No.

Hammer Wt. 140 lb Boring Started 7-19-94
Hammer Drop 18"
Casing Left N/A Boring Completed 7-21-94
Subsurface Water Data 36.0 Page ____
Obs. Well ____
Drilled By MOBILE DISTRICT DAVID BOWDEN
Mfg. Des. Drill FAILING 314
Inspected By: Douglas B. James
Classification By: ____
Classification By: ____

DEPTH (ft)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
1					DRILLER USE 8" AUG TO ADVANCE boring TO 8', SET 7' 6" 6" CASING MIX POLY-SAL. USE 5 5/8" ER TO ADVANCE Boring	COMPACTED PERVIOUS FILL W/ GRAVS. & Cobbles.
2						
3						
4						
5						

GENERAL REMARKS:

Site BLACKWATER DAM	Boring No. FD-94-3	Page 3 of 8

DEPTH (ft)	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
6					CONTD W/ 5 5/8 RB TO ADVANCE boring	COMPACTED PERVIOUS FILL W/ GRAV. & COBBLES
7						
8						COMPACTED PERVIOUS FILL W/ GRAV, RK. FRAGS
9						
10						
11						
12						
13						

Site BLACKWATER DAM	Boring No. FD-94-3	Page 4 of 8

DEPTH (ft)	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
14						COMPACTED PERVIOUS FILL w/ GRAV & RK. FRAGS
15						
16						d-16.0
17	1-1-7			18 23 28 37	SAMPLE w/ 1 3/8" ID SPLITSPOON USING 140 lb. Hammer w/ 18" drop.	Gray & brown Silty (10-20) SAND w/ Tr Gravel 1/4"-1/2" SM
18	1-R-7			29 60		Brown Silty (14) SAND w/ Gravel (23) 1/4"-1/2"
19						
20						
21	M-1-7			29 60 60		Brown Silty (10-20) SAND w/ Tr Gravel 1/4" - 1/2"
22						

Site: BLACKWATER DAM

Boring No. FD-94-3

Page 5 of 8

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. / CORE RECVY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
23	J-4			60 60	SAMPLE W/ 1 3/8" ID SPLITSPOON USING 140 lb. HAMMER W/ 18" DROP.	Brown Silty (20-30) GRAVEL w/ Sand (20-30) GM
24	J-5			60 72		Brown Silty (10-20) SAND w/ Tr. Gravel 1/4" - 1/2" SM
25						
26	J-6			40 60		Brown Silty (10-20) GRAVEL GM
27						
28	J-7			48 60		Brown Silty (10-20) SAND w/ Tr. Gravel 1/4" - 1/2" SM
29						
30	J-8			60		

CONTD. ON NEXT PAGE

Site	Boring No.	Page / of
BLACKWATER DAM	FD-94-3	4 of 9

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
31	J-8			60	SAMPLE W/ 1 3/8" ID SPLITSPOON W/ 140lb Hammes, 18" drop	Brown Silty (10-20) SAND w/ Gravel 1/4"-3/4" SM
32	J-9			50 / 60		
33						
34	J-10			55 / 60		
35						
36	J-11			54 / 60 / 60		
37						
38	J-12			60 / 60		Brown Silty (10-20) SAND w/ Gravel 1/4"-1"
39						

Site: BLACKWATER DAM | Boring No.: FD-94-3 | Page 7 of 8

DEPTH	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. / CORE REC'VT	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
40						
	M-1			39		Brown poorly graded Si/Hy(5-10) SAND w/Tr Gravel 1/4" max
				60		
41				60		SP-SM
41.2						TPRK 41.2
42				B		P-1 RAN - 4.9 REC - 4.2 L - 0.7 WATER RETURN - 100% HYD PRESS - 150-200 DRILL ACTION - ROUGH
				X		
43						
				1		
44						Gray Coarse Granitic Gneiss
				OF		
45						
				1		
46						
47						

Site	Boring No.	Page 8 of 8
BLACKWATER DAM	FD-94-3	

DEPTH (ft)	CORE/SAMPLE NO.	CORE/SAMPLE SIZE	CORE/SAMPLE DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
48				B X		P-2 RAN - 5.0 REC - 5.0 L - 0 0 DRILL TIME-32MINS 1 ACTION-SMOOTH HYD PRESS - 150-200 WATER RETURN - 80%
49				1		
50				0 F		
51				1		
51.9						BOH 51.9

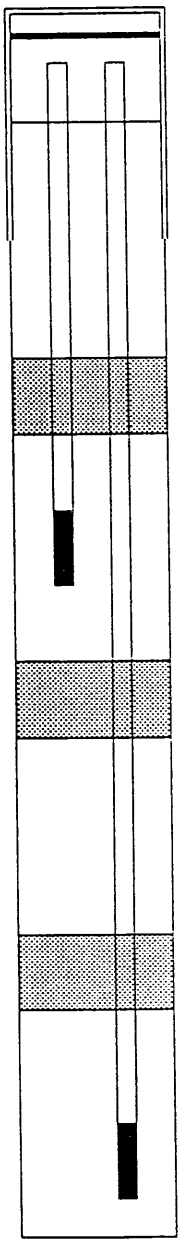
Boring No. FD-94-3

PLATE A.42

PIEZOMETER INSTALLATION LOG			PAGE of
Project	BLACKWATER DAM	Date	7-24-94
Northing		PZ Number	PZ-3: A & B
Easting		Hole Number	FD-94-3
Start	7-19-94	Inspector	Jones D
Complete	7-21-94	Pre-Install Pz Length	
Sounding	2A-51.0 2B-38.0	Riser Cut-off	

Piezometer "A" stick-up is always longer than piezometer "B".

All Depths are taken from the ground surface.



	PZ-A	PZ-B
Piezometer Stick-Up	2.4	2.5NA
Ground Surface	0	
Type of Fill Material	RANDOM FILL	NA
Depth Bottom of Casing	7.6"	NA
Dia. PVC Pipe /Schedule	3/4"	3/4"
Depth Top of Plug	28.0	NA
Depth Bottom of Plug	32.0	NA
Type of Fill Material	PLAY-SAND	NA
Depth Piezometer Tip	NA	38.0
Depth Top of Plug	N/A	NA
Depth Bottom of Plug	N/A	NA
Type of Fill Material	PLAY SAND	NA
Depth Top of Plug	40.0	NA
Depth Bottom of Plug	44.0	NA
Type of Fill Material	PLAY-SAND	NA
Depth Piezometer Tip	51.0	NA

Notes:

PLATE A.43

Site: BLACKWATER DAM
Boring No: FD-94-3

SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-20				-	36.0	PZ-3A
					±21.7	PZ-3B
					-	

Note: Depths are in feet below original ground

BORING LOCATION SKETCH

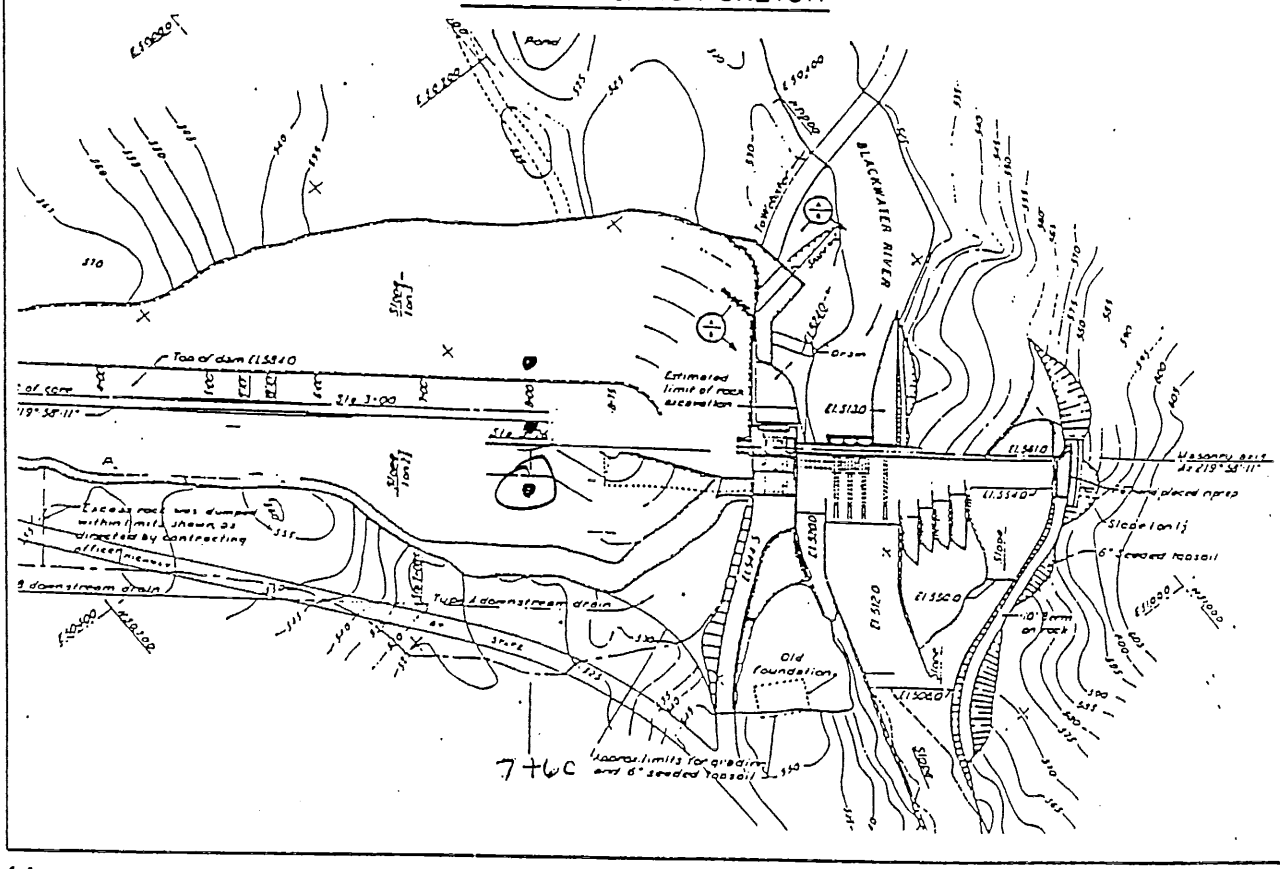


PLATE A.44

Boring No. FD-94-3

FIELD LOG OF TEST BORING IN ROCK

SITE BLACKWATER DAM HOLE NO. FD-94-3 PAGE

DATE	DEPTH FT. FROM	DEPTH FT. TO	RUN FT.	RUN REC'V'Y FT.	REC'V'Y %	DRILLING BEHAVIOR: FEED	DRILLING BEHAVIOR: WATER	DRILLING BEHAVIOR: REASON FOR PULL	ACTUAL DRILLING TIME	BIT NO. SIZE AND TYPE	ADDITIONAL REMARKS
7-20-94	42.0	46.9	4.9	4.2		150-200	80%	BIT NO GOOD	2 HRS 10 MINS	HQ 2¾X3⅞	NEW BIT 94 PW 111
	46.9	51.9	5.0	5.0		150-200	80%	BBL FULL	32 MINS	〃	〃

TOTAL BED ROCK DRILLED 9.9 FEET

TOTAL BED ROCK RECOVERED 9.2 FEET

BED ROCK RECOVERY _____ PERCENT

DRILLER DAVID BOWDEN

INSPECTOR DOUG JONES

NED FORM DEC 63 130

REPLACES EDITION OF APR 63 WHICH MAY BE USED UNTIL EXHAUSTED

PLATE A.45

PLATE A.46

09/02/94

SITE: Blackwater Dam BORING NUMBER: FD94-03

DATE: 07/21/94 PIEZOMETER NUMBER PZ-3A

START TIME: 12:40:00 DATUM ELEVATION: 567.24

POOL ELE.: 516.10 INTIAL WATER DEPTH FROM TOP OF RISER 36.00

LAPSE TIME	CLOCK TIME	DEPTH	ELEVATION
00:00:00	12:40:00 PM	0.00	567.2
00:00:15	12:40:15 PM	2.00	565.2
00:00:30	12:40:30 PM	4.30	562.9
00:01:00	12:41:00 PM	10.20	557.0
00:02:00	12:42:00 PM	14.60	552.6
00:04:00	12:44:00 PM	24.50	542.7
00:08:00	12:48:00 PM	33.90	533.3
00:15:00	12:55:00 PM	37.00	530.2
00:30:00	01:10:00 PM	37.80	529.4
01:00:00	01:40:00 PM	37.80	529.4
02:00:00	02:40:00 PM	37.80	529.4

DATE REVISED: 09/02/94

INSPECTOR: Doug Jones

REMARKS:

BWPZ03AF.WK4

09/02/94

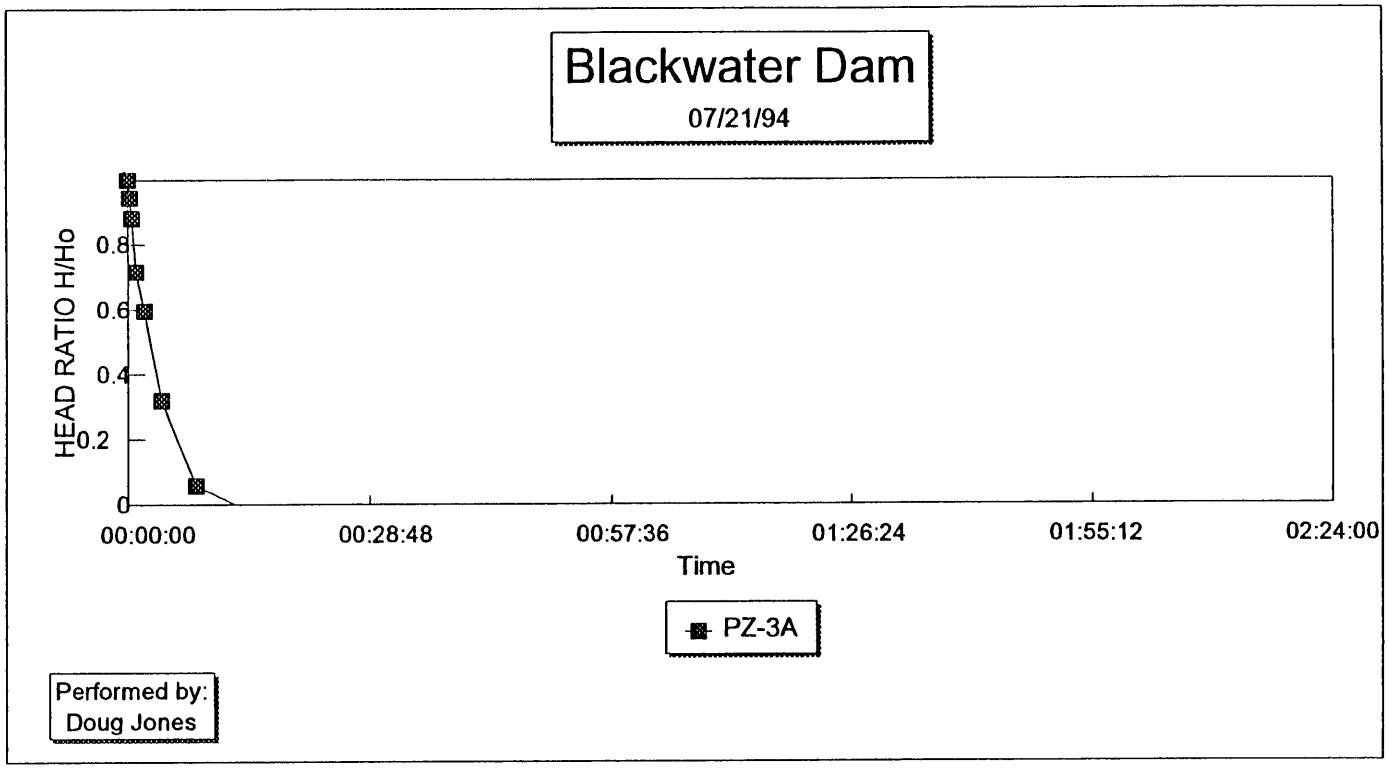


PLATE A.47

BWPZ03AF.WK4

PLATE A.48

09/02/94

SITE:	Blackwater Dam	BORING NUMBER:	FD94-03
DATE:	07/21/94	PIEZOMETER NUMBER	PZ-3B
START TIME:	12:45:00	DATUM ELEVATION:	567.30
POOL ELE.:	516.10	INTIAL WATER DEPTH FROM TOP OF RISER	21.10

LAPSE TIME	CLOCK TIME	DEPTH	ELEVATION
00:00:00	12:45:00 PM	0.00	567.3
00:00:15	12:45:15 PM	0.10	567.2
00:00:30	12:45:30 PM	0.20	567.1
00:01:00	12:46:00 PM	0.40	566.9
00:02:00	12:47:00 PM	0.60	566.7
00:04:00	12:49:00 PM	1.00	566.3
00:08:00	12:53:00 PM	2.00	565.3
00:15:00	01:00:00 PM	3.30	564.0
00:30:00	01:15:00 PM	6.80	560.5
01:00:00	01:45:00 PM	10.50	556.8
02:00:00	02:45:00 PM	12.80	554.5

DATE REVISED: 09/02/94

INSPECTOR: Doug Jones

REMARKS:

BWPZ03BF.WK4

09/02/94

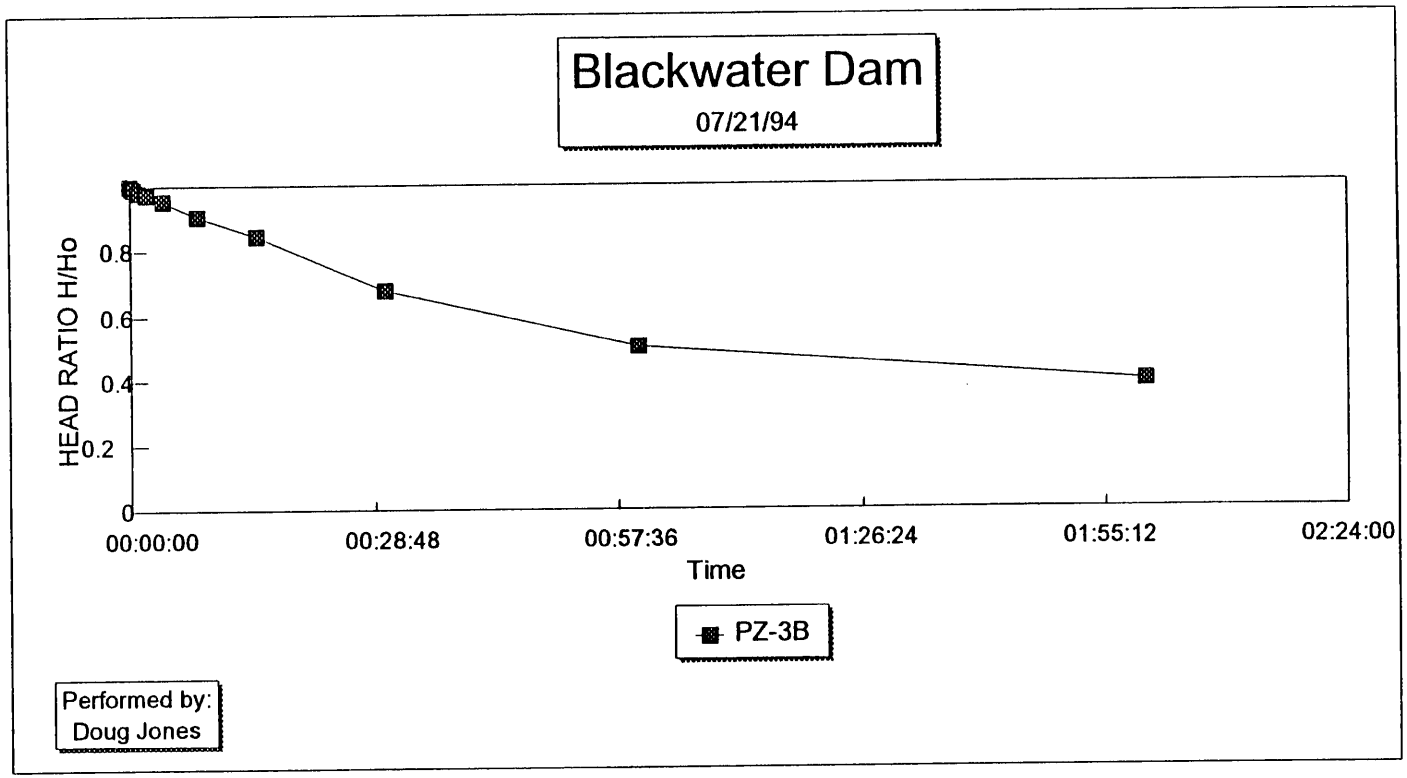


PLATE A.49

BWPZ03BF.WK4

Standard 1

The following standards and procedures are employed for Crest Monument Surveys at Blackwater Dam

STANDARDS FOR SETTLEMENT SURVEYS

1. Control points are stamped brass disks preferably set in a ledge area. Where no ledge is available, they are set in concrete bounds placed flush with the ground.

2. Control points are set in areas such that the maximum possible number of crest monuments on the dam are visible.

3. Control points are tied into four reference points by distance. This provides a check each time they are occupied for settlement surveys or allow them to be replace if found to be destroyed.

4. Distances are read and recorded between settlement bounds. Both distance and angle are read and recorded from the control points that are being occupied to locate each settlement bound on the dam.

5. In locating each settlement bound, a control point will be occupied setting 0-00'-00" (referenced line of site) on a second control point, reading and recording both interior and exterior angle closure, along with distances through each settlement bound located on the dam. Each settlement bound is located from a minimum of two control points. These locations are third order, class II survey with relative accuracies of not less than 1 part in 5,000.

6. Levels are run from control points through each settlement bound on the dam with a return run back into the control points to check the elevation closure on the run. Closure tolerance should be no greater than 0.05'. These levels are third order, class I survey with relative accuracies not less than 1 part in 10,000.

7. Crest monument surveys are performed using Topcon EDM Total Stations and recording both horizontal angles and horizontal distances.

PROCEDURE FOLLOWED FOR SETTLEMENT SURVEYS

The horizontal and vertical monitoring plan for settlement bound movement points employed a combination of triangulation and trilateration angle and distance techniques to survey the control network. Control points, in the form of stamped brass disks, were placed on the dam structure in a location that is clearly

visible from the control points. Horizontal coordinates of the control points are based on the State Plane Coordinate System. Elevations of the control points are bawd on the National Geodetic Vertical Datum (NGVD). Control points are occupied utilizing an EDM Total Station; observed distances and angles (interior and exterior angles), between control points and settlement bound establishing permanent bench marks. Standard leveling techniques are followed. Levels are double run and the means of the front and back runs were computed and recorded.

DATA ADJUSTMENT

A combination of triangulation and trilateration surveying techniques are applied. Each crest monument is located from two control points and two sets of coordinates are calculated using adjusted field angles and compliments and EDM distances. The two sets of coordinates are averaged to give a net result. The averaged coordinates are then established on each settlement bound for use in determining shifts in the dam surface structure over a period of years by comparing repetitive surveys.

Blackwater Dam
Piezometer Reading Schedule

1. General. Piezometers are utilized to measure ground water levels and pore water pressures both in the foundation and the embankment of the dam. Experience has shown that installation of piezometers in the embankment and their foundation provides significant data indicating the magnitude and distribution of pore pressures and their variations with time and also patterns of seepage, zones of potential piping, and the effectiveness of under seepage control.

2. Piezometer Tidings. At the present time, files are maintained for dams which have operating piezometers and most of the data is put on the computer. Data is transmitted to GED in writing by the project manager. Piezometer data should be reduced in the field and each reading compared with previous data; thus, if a piezometer has an unusual reading, the reading can be checked immediately. Pool elevations and rainfall data should recorded simultaneously with the piezometer readings.

a. Reading Schedules.

(1) Routine. During periods when the reservoir level is below the 20 foot stage (535 feet NGVD), a reading of all piezometers should be taken at least once a month. These readings, along with the previous 24 hour rainfall, time of reading, and pool stages, should be sent to the Geotechnical Engineering Division (GED). When access to piezometers is made hazardous due to snow or ice, the readings may be deferred until safe access is possible.

(2) High Pool. During periods when the reservoir is above the 20 foot stage (535 feet NGVD), readings of all piezometers should be made on a daily basis. previous 24 hour rainfall, time of reading, and pool stages should be recorded simultaneously with piezometer readings. On a falling pool, daily readings should continue until five day after the pool stage returns to 5 foot (Ele. 520.0).

b. Data Collection.

(1) Location Maps. A general plan of the project showing the location of the piezometers and the corresponding identification number for each piezometer is provided to eliminate identification and data recording.

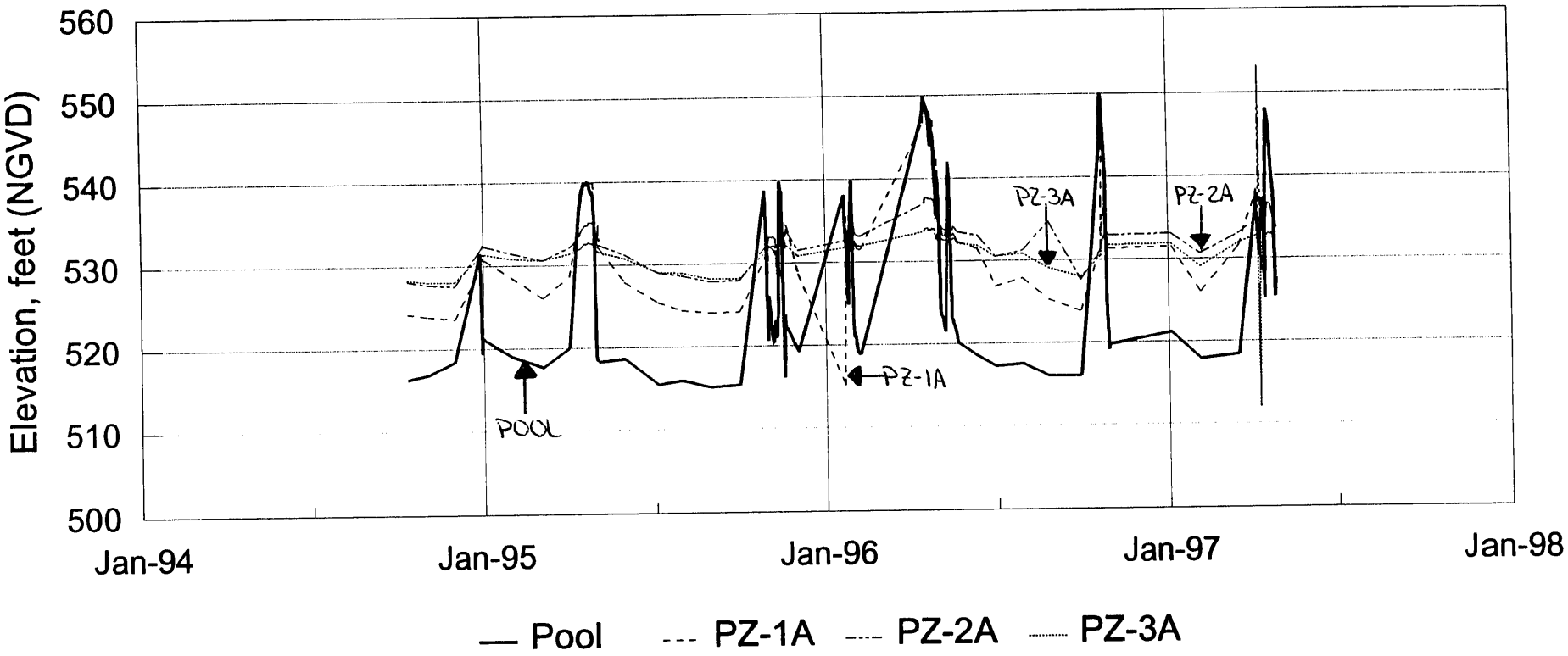
(2) Data Collection Table. A table listing the piezometer identification number, station and offset, as well as piezometer top and tip elevation is provided for recording and submitting piezometer readings. It should be noted that when two piezometers are located in the same protective casing, each shall be designated with a number as well as an "A" or "B". The letter "A" will indicate the deeper piezometer tip and the letter "B" shall designate the more shallow tip for each location.

(3) Destination. All data should be sent to the following address:

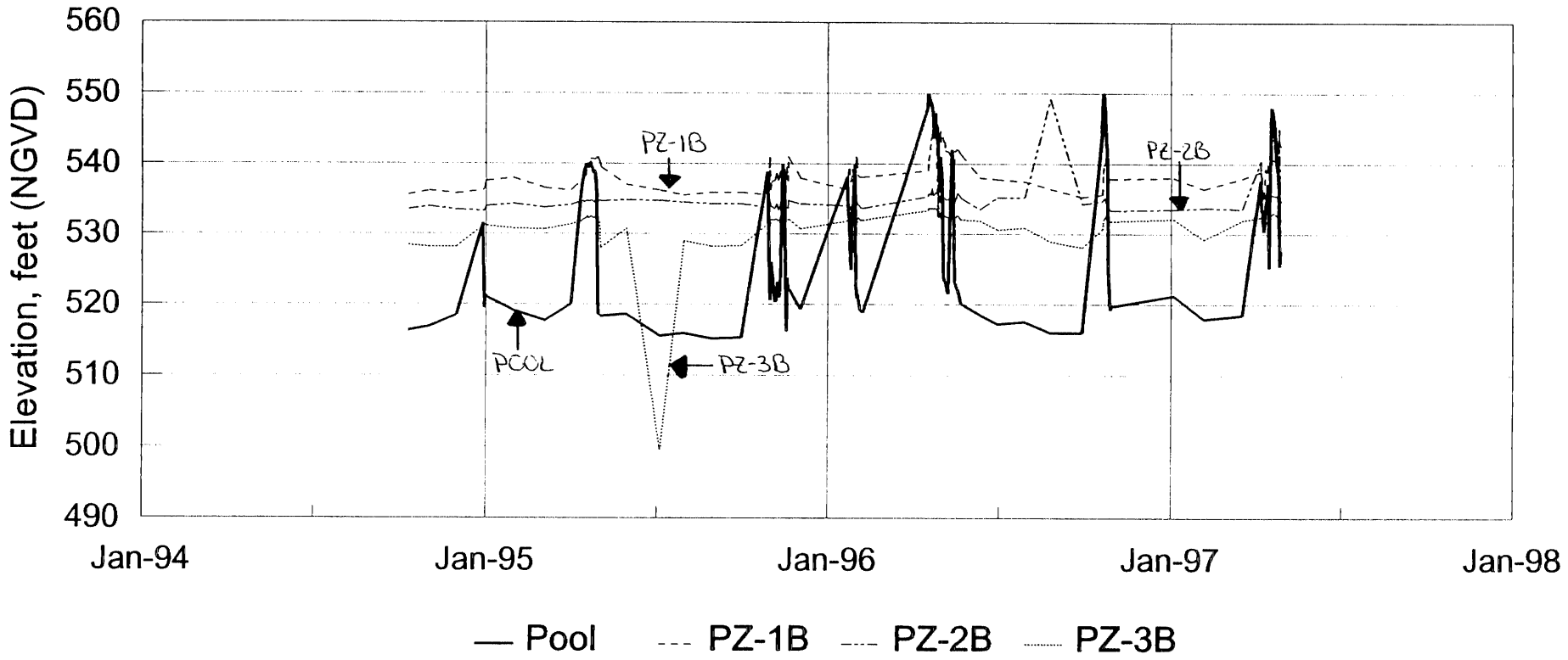
CENEN-ED-GD
RE: PIEZOMETERS
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

(4) Special Conditions. If unusual changes in readings develop or if piezometers become inoperable, Geotechnical Engineering Division should be contacted immediately.

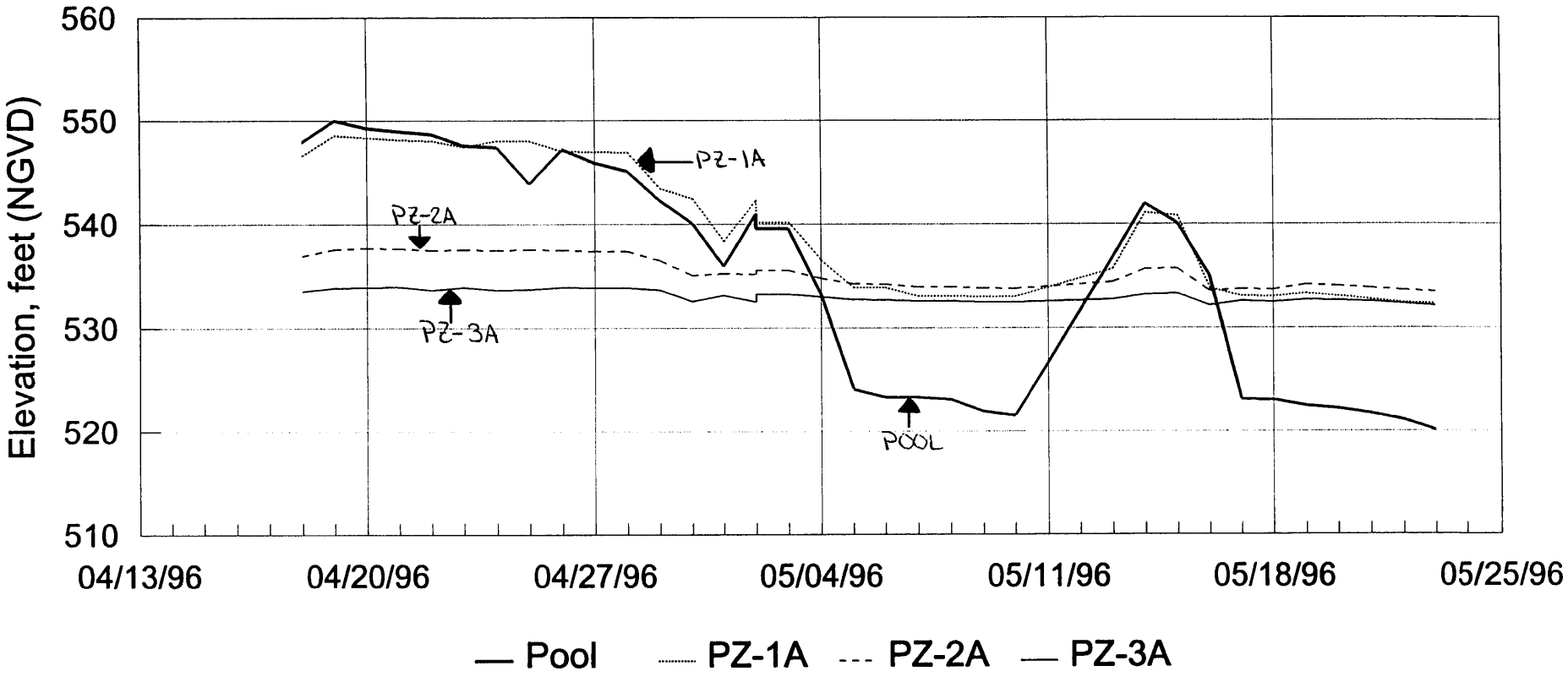
Piezometer Time History
Pool Elevation, PZ-1A, PZ-2A, and PZ-3A



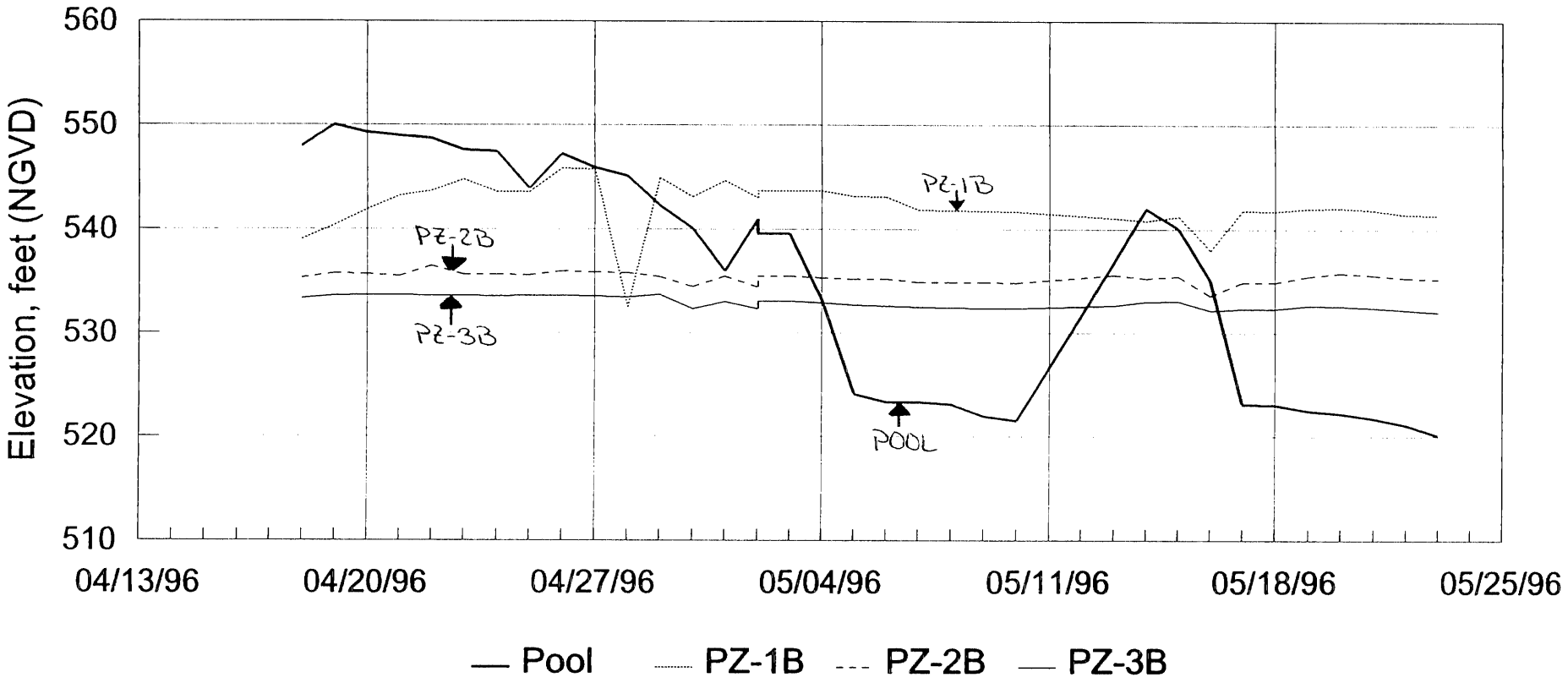
Piezometer Time History
Pool Elevation, PZ-1B, PZ-2B, and PZ-3B



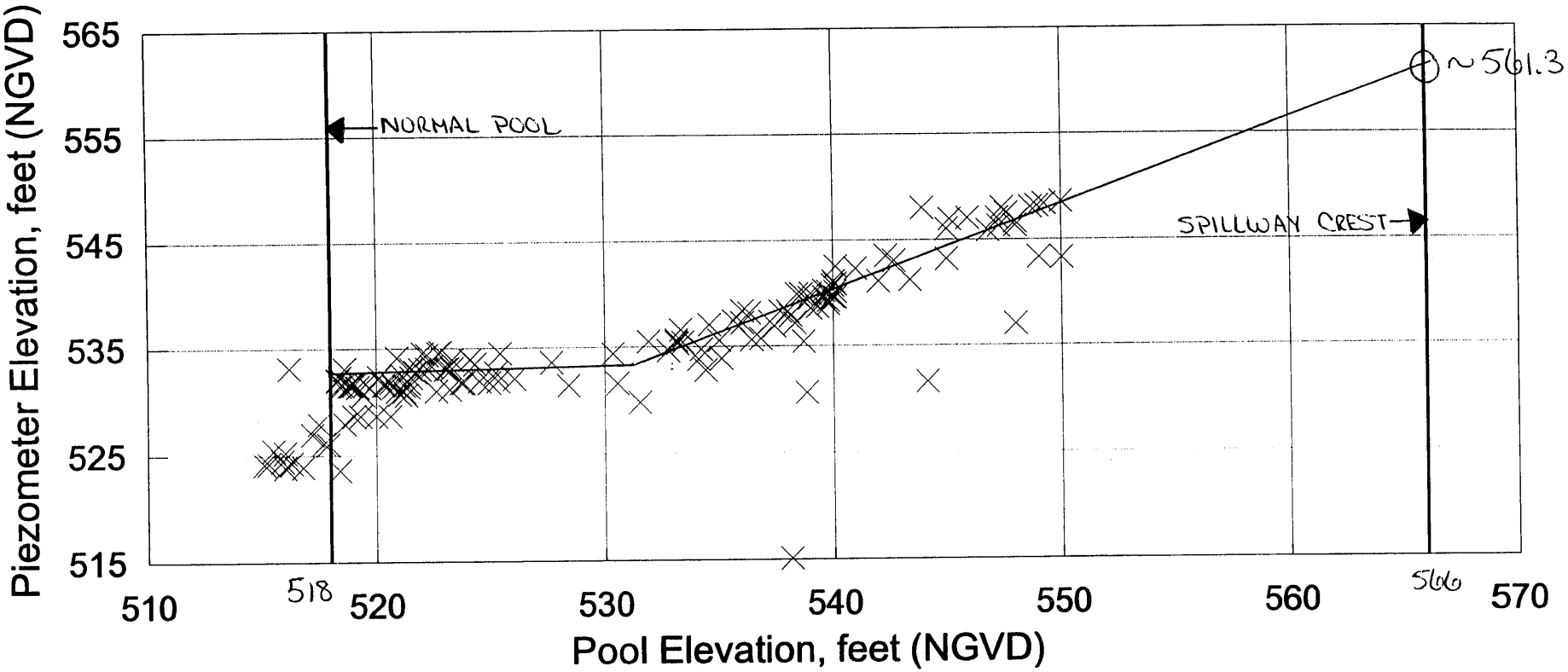
April 1996 High Pool Event
Pool Elevation, PZ-1A, PZ-2A, and PZ-3A



April 1996 High Pool Event
Pool Elevation, PZ-1B, PZ-2B, and PZ-3B



Piezometer Elevation vs. Pool Elevation
PZ-1A



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Blackwater Dam

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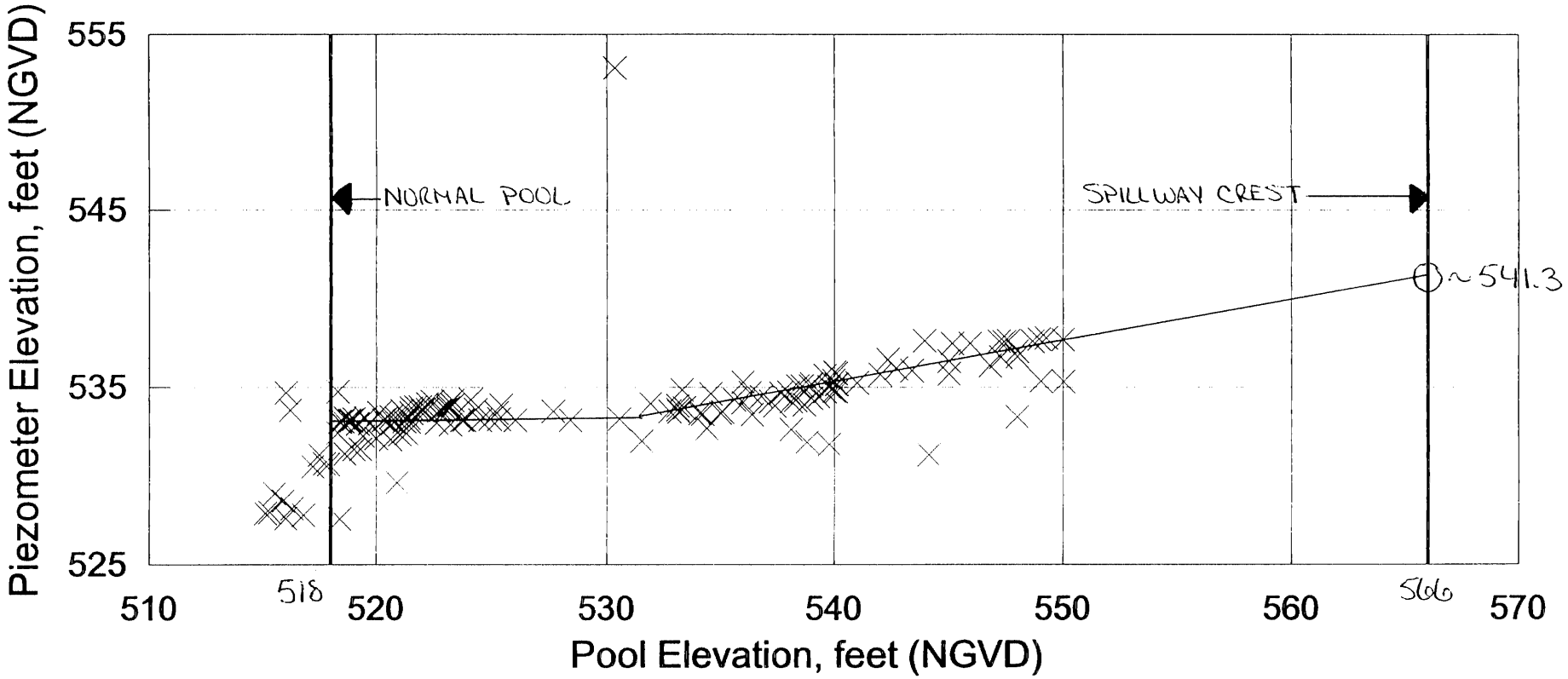
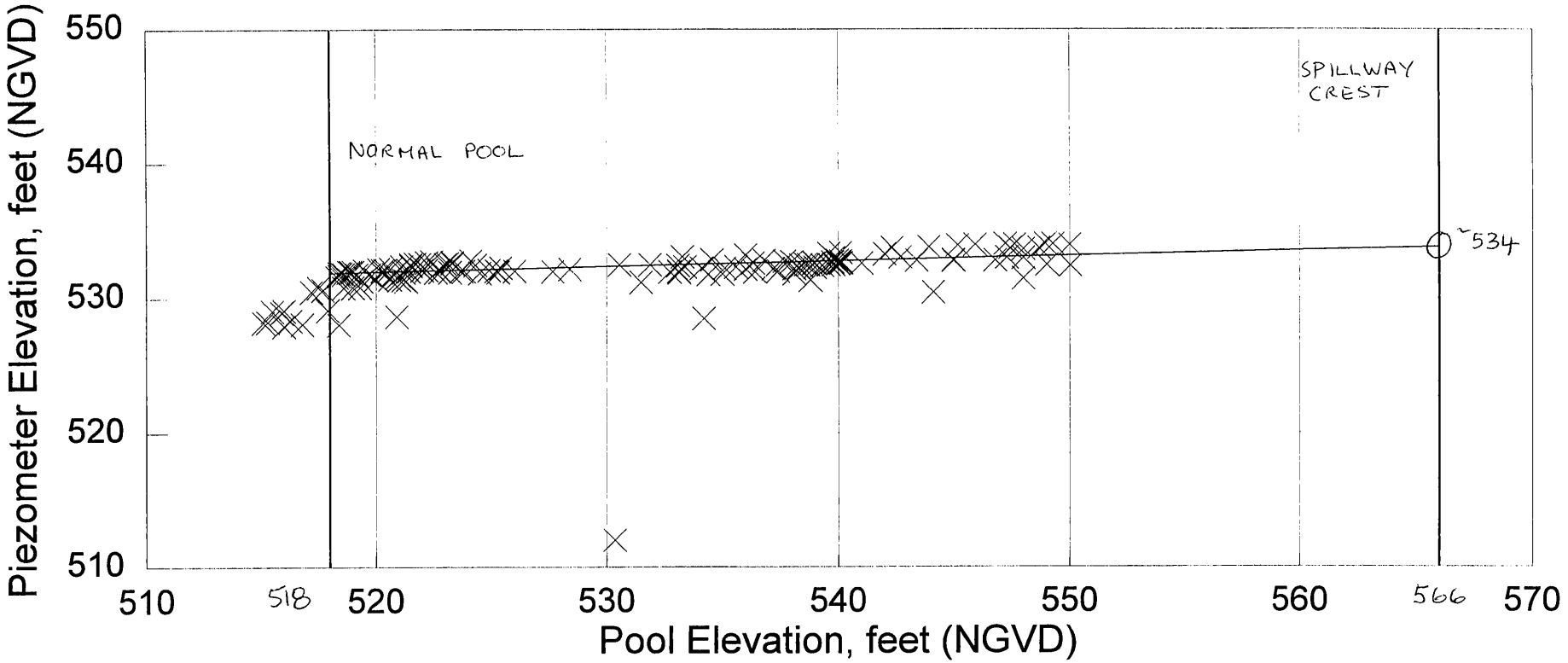
PLATE E.1

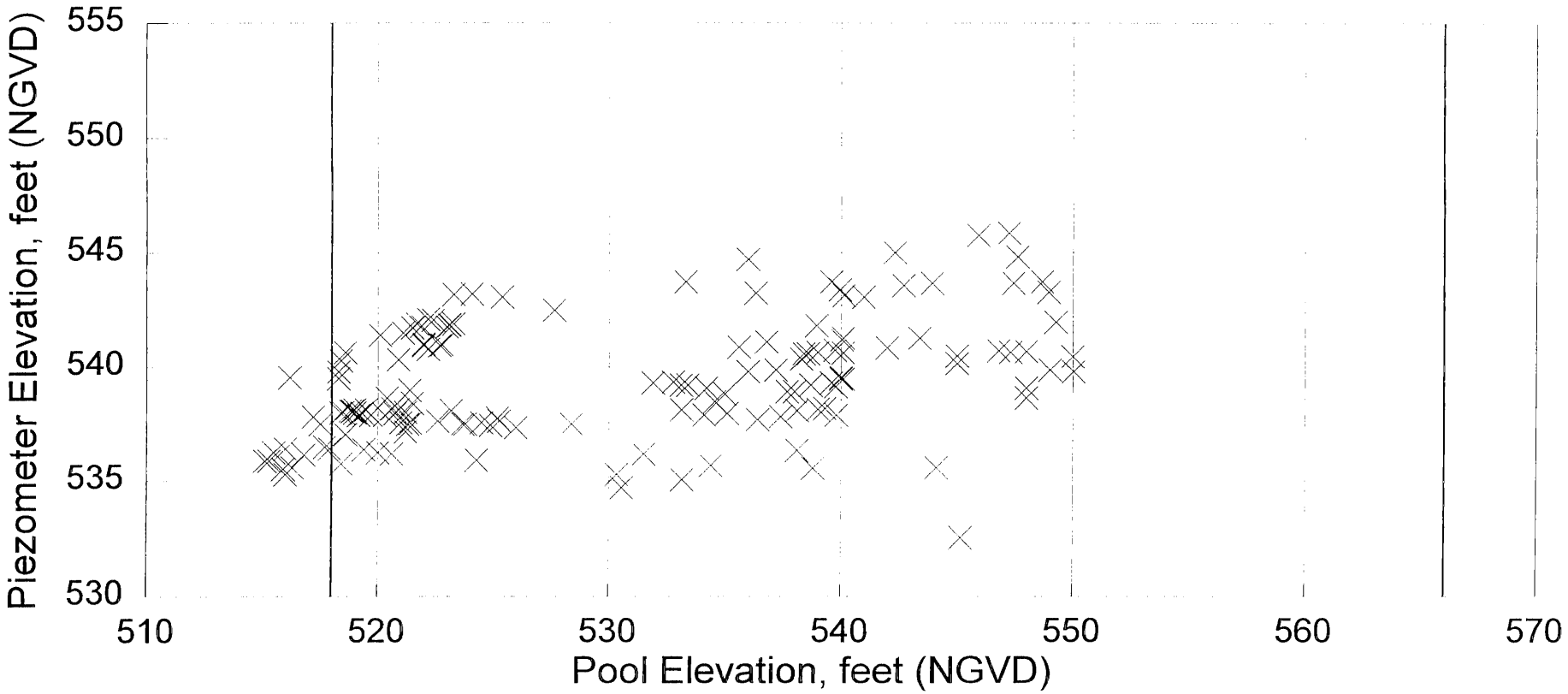
Piezometer Elevation vs. Pool Elevation
PZ-2A



Piezometer Elevation vs. Pool Elevation
PZ-3A



Piezometer Elevation vs. Pool Elevation
PZ-1B



Piezometer Elevation vs. Pool Elevation
PZ-2B

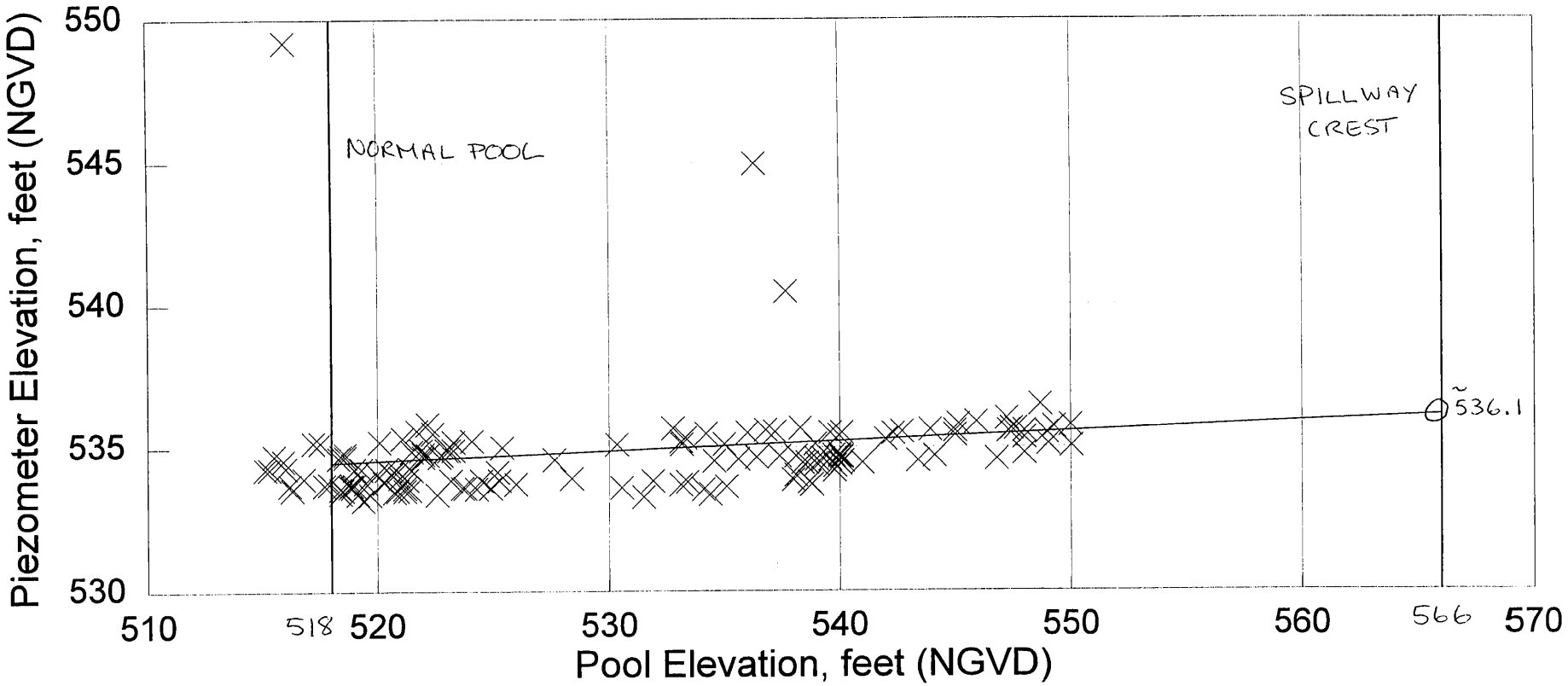


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PLATE E.5

Piezometer Elevation vs. Pool Elevation
PZ-3B